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FIG. 2. CEMENT GUN AT WORK ON PANAMA CANAL.

THE CEMENT GUN

BY WILLIAM A. JORDAN.*

Following the first commercial exploitation of cement, considerable time elapsed before the value of concrete was generally recognized. Judged by laboratory tests, where the necessary ingredients of mortar or concrete could be perfectly proportioned and carefully incorporated, results were fairly satisfactory; in practice, however, even up to the present time it has never been possible to closely approximate laboratory results.

For example, taking so simple an operation as the mixing of cement mortar, composed of one part of cement and two of sand, in practice it will be found difficult, if not impossible, to obtain the desired consistency if the theoretical amount of water required to temper the mass is used. On the one hand the theoretical amount of water forms a mortar too stiff to handle, while, on the other hand, any excess of water weakens the mortar by causing voids equal in extent to the bulk of unabsorbed water present.

In the cement gun process, no excess of water can remain in the mortar to later cause voids, neither is it possible for the finest particles of the cement to begin to set before the mortar is placed. Experiments have proved that when cement mortar is tempered with water at the instant that it is deposited in

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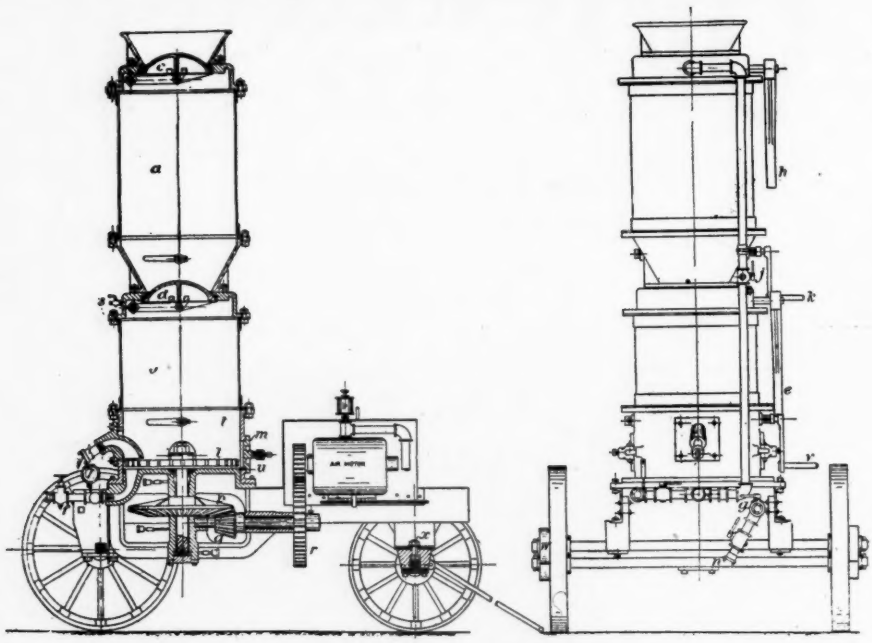


Fig. 1.—CROSS SECTION OF CEMENT GUN.

Dry mixed material placed in cylinder "a." Valve "c" closed and air pressure equalized in cylinders "a" and "b." Valve "d" opened and material drops into lower cylinder "b." The process is then repeated. The feed wheel "s" is revolved by an air motor through the gears "r" and "p." Compressed air admitted through valve "f" blows the material upward and out through the goose-neck shown above the air pressure gauge into a flexible hose.

place, the strength of the mortar is greatly increased. This increase in strength is due to more perfect mixing, to the elimination of loss by the premature setting of a considerable portion of the particles of the cement, and to the greater density of "gun" placed mortar.

It is well understood that perfection in certain arts can be achieved only by the skilled hand and trained eye of the master craftsman. It is not desirable to substitute the precision of a machine for the chisel of the sculptor or the brush of the painter. But in certain industrial arts, the hand worker, however skilled he may be, must be aided and supplemented by machinery. It is not so long ago that the invention of the first power loom, forever ended the toil of countless hand weavers, and it is still within the memory of men when the sickle was for all time retired by the modern reaper.

Among the various materials used in building construction, Hydraulic Cement appears to be one for which machine application might be most rationally expected, and accordingly, it is with this material that inventors have experimented more extensively than with any other. The solution of the problem came with the discovery of the so-called "Cement Gun." As a matter of fact, this is not a "gun" in the ordinary meaning of the word, but it was so designated from the fact that the material is projected from the nozzle with considerable force and literally "shot" into place.

BEGINNING OF THE CEMENT GUN.

Strange to relate, the apparatus was not invented by an engineer or a cement worker, or even by a contractor or builder. It was originally conceived by Mr. C. F. Akeley, a taxidermist of Chicago. His idea for the use of the Cement Gun was to rapidly and economically build up forms over which the skins of the larger mammals such as elephants and hippopotami might be placed.

Mr. Akeley was also a member of the Field Museum Committee and had charge of the

remodeling and preserving of one of the old World's Fair buildings in Jackson Park, Chicago, that had been given to the Field Museum Association. He conceived the idea of enlarging the cement gun and then covering the entire building with stucco work by means of it. The experiment was highly successful and the work was performed rapidly and well within the estimated cost.

FIG. 3.

This first practical work done by the cement gun at once demonstrated its possibilities beyond a doubt. The apparatus was then studied in the laboratory and subjected to various practical tests. Also different types of "guns" have been developed and changes have been made as experiments have suggested.

The cement gun, Fig. 1, consists essentially of a hopper into which the cement materials are placed, a hose connected to the bottom of the hopper through which the dry mixture is forced by compressed air, and a specially designed nozzle at the end of the hose to which another hose supplying water is attached.

The dry materials are forced through the hose by the air pressure, hydrated at the nozzle, and shot into place with a muzzle velocity due to a pressure of 35 pounds. The resulting product is of a quality never before attained by any other machine process or by hand. The combination of the elements, cement and water, necessary to produce the plastic material, takes place in transit and the latter is not disturbed after it is placed.

It is a well known chemical fact that the instant water is brought into contact with cement, the initial set, or the chemical combination begins. This initial set must be looked upon as the commencement of that hardening which gives the mass its ultimate strength. Hence, subsequent manipulation tends to disturb this initial set, and consequently must weaken the product. These objectionable features are entirely overcome by the cement gun process; the hydration taking place in transit and immediately before and during emplacement, and the chemical combination or initial set taking place where it belongs; i. e., in its final resting place and not on the mixing board.

The Cement Gun employs or appropriates only the necessary amount of water for the hydration of the cement, and because the materials are projected with considerable force, all surplus water and air are expelled. The product is a non-porus, impermeable mass, possessing the maximum density, and by reason of these qualities, it is practically waterproof.

That the remarkable results attained thus far are possible may be explained as follows:

FIG. 4.

Consider for a moment the constitution of an ideal concrete. We will assume that that part of the mass, consisting of broken stone and sand, is so proportioned, relatively to size and fineness, that it contains the least possible percentage of voids. An ideal mixture would result if cement in sufficient quantity were added to completely fill every void, to perfectly surround and cover each stone and each particle of sand, so that no two surfaces of either sand or stone, throughout the entire mass were in direct contact. Thus graded, and with the use of no more water than the amount actual-

ly required for the perfect hydration of the cement, the mixture would constitute the ideal concrete.

We are all familiar with the Sand Blast; a powerful current of air into which, at some point prior to its escape at the nozzle, sharp, clean sand is introduced. The escaping current of air imparts a high velocity to the particles of sand as they leave the nozzle, the force exerted being sufficient to cause them to quickly wear away any hard, unyielding substance against which the blast may be directed, such as iron casting, stone, etc. If, instead of being projected against a hard substance, a sand blast is directed against a surface of a comparatively soft and sticky nature such as ordinary wax, a very curious and unexpected thing happens. The particles of sand, instead of instantly tearing and wearing the wax away, as might be expected, penetrate the surface and stick, thus becoming a part of the mass itself. This process is continued until the wax is, as it were, saturated, and no more sand can find lodgment therein; in other words, the wax arms itself against attack with the sand itself, and thus the most powerful sand blast is rendered harmless.

Let us consider now what might be expected to happen if a certain proportion of powdered wax were introduced into the air blast with the sand, and the combined material directed against some hard surface, a sheet of boiler iron, for instance. Of course, the first particles of sand would strike the iron and bounce off, much as a pebble does when thrown against a wall; but, being soft and sticky, every atom of wax would adhere, and within a few moments the entire surface of the iron would be protected by a thin coating of wax. After this coating had become thick enough to enable the grains of sand to embed themselves threin, they would cease to bounce off as at first, but would stick and become a part of the mass or coating itself. It is easy to understand that, if the process were continued, the sand and wax could be made to form as thick a coating on the surface of the iron as might be desired.

If in the above experiment in place of wax we introduce cement and water, the operation of the Cement Gun is easily comprehended. When the nozzle is first directed against any hard surface, the particles of sand do not at first adhere; they fall away until a coating of cement sufficiently thick is formed to enable the sand to embed itself. The importance of this feature will be better understood when it is realized that the effect in practice is to deposit a thin layer of practically neat cement where the new work joins the old, and after hardening, if a test piece is broken, it will be found that this joint or initial surface of adhesion is the strongest part of the mass.

When considering "gun" made concrete, it should be borne in mind that the powerful air blast imparts a great velocity to the particles of sand. By means of the sand blast, ordinary dry sand will wear its way through iron or steel with incredible speed. In the Cement Gun the high velocity imparted to the mixture of sand, cement and water as it is

FIG. 5.

thrown upon a surface to be coated is of the utmost importance in producing a concrete of maximum density.

In the cement gun the sand and cement are first mixed together in correct proportion while dry. This dry compound is deposited in the hopper, from which it is fed into a powerful blast of air which conducts it through a suitable length of ordinary rubber hose until the nozzle is reached. Here, in the form of a fine spray, the water necessary for hydration is added at a pressure slightly in excess of the air pressure. The velocity with which the materials are traveling, however, is so great —300 feet per second—that hydration in reality takes place in the air, after leaving the noz-

FIG. 6.

FIG. 8.

zle, and is completed as the mixture is deposited. It is, of course, impossible to regulate the water thus admitted to precisely the amount theoretically required, as a very small variation in the air pressure alters the amount of dry material flowing from the machine, nor is such fine adjustment necessary or advisable. The mixture of sand, cement and water strikes the object or surface on which it is deposited with such force, that any surplus water contained is continually driven to the surface and flows away, just as in tamping and ramming a mass of wet concrete, a percentage of the surplus moisture is forced to the surface.

The cement gun has been used on a number of engineering projects very successfully. Probably the most prominent place where the Gun has been used is the Panama Canal. Here it was employed to coat the disintegrating rock of the Culebra cut with concrete. See Fig. 2.

The New York Central & Hudson River R. R. Co. are using the cement gun process for coating the steel work in their new 42nd street terminal. This work has been done without forms, or centering of any kind, and a coating of two to three inches of concrete has been applied to all structural members. It is necessary that steel be thoroughly clean and free from rust. On account of vibration from trains, the concrete is reinforced with various sizes of wire mesh.

The sea wall at Lynn, Mass., was repaired by Mr. J. R. Rablin, Chief Engineer of the Metropolitan Park Commission, in a very satisfactory manner by means of the cement gun. Here it was necessary to contend with the tides, but it was found that they had no effect when the cement was once in place.

The engineers of the Water Supply Department of the City of Baltimore have investigated the Cement Gun Process and have decided that it could be used to advantage for lining an 8 mile brick water tunnel, between the new dam at Loch Raven and the City of Baltimore. This tunnel is being changed from a gravity tunnel to a pressure tunnel. In the

FIG. 7.

FIG. 9.

case of this water tunnel, it will be necessary to work four hours and allow the concrete to set during four hours, and then turn the water on. We have thus seen that not only have we now an apparatus which enables us to deposit concrete in various ways not hitherto found practicable, but also with the same apparatus we can obtain a concrete which has qualities and properties not secured with the best hand or machine made mixtures.

Whereas formerly, concrete layers less than a few inches thick could be deposited only by means of slow, laborious and costly methods, either by plastering, or, if space allowed, by means of comparatively expensive molds or forms, the same result may be accomplished with great rapidity and with the most flexible of tools,—a blast of air. Again, while with hand plastering it is practically impossible to secure a uniform deposit that will resist the forces of nature which tend to destroy the continuity of such a coating from the moment it is made, the concrete deposited through the agency of one of those destructive elements itself is so homogeneous, dense, and cohesive that even the flames cannot destroy its continuity.

The following notes are appended in further explanation of the illustrations:

Fig. 2. Concrete gun at work on the Panama Canal. Concrete re-enforcement necessary to prevent the falling of overhanging andesite. Original method shown on the right, concrete gun at work on the left. Thickness of hand-made revetment wall, 4 inches to 4 feet. Average thickness of gun concrete, 2 inches. Cost of gun work, less than 20 per cent. of hand work per unit of area.

Fig. 3. Sea wall at Lynn, Mass., showing destructive work of tides and storms.

Fig. 4. Same sea wall patched and repaired by the cement gun.

Fig. 5. Cement gun in action, coating concrete block houses.

Fig. 6. Wooden frame of house designed to be covered with stucco applied by the cement gun process. Wooden lath and hand plastered on the inside.

Fig. 7. Second stage in the cement gun process. The above frame covered with building paper and reinforcing wire.

Fig. 8. (Not the same house). First coat of stucco applied to house. Note style of scaffolding, method of covering windows and corner strips.

Fig. 9. The finished concrete house as left by the concrete gun. No hand work necessary to complete work of gun.

TEAM BELOW ATMOSPHERE COMPRESSING AIR TO ONE HUNDRED ATMOSPHERES

A compressed air haulage system has been installed in the mines of the Bergban colliery, New-Essen, Germany, using the exhaust steam from the colliery hoisting engines for running the compressor. The ultimate work of the compressor was the supplying of five pneumatic locomotives each having 170 ton-miles of work per day, the storage pressure required being 1,470 lbs., or 100 atmospheres, and the compression being performed in four stages.

Figs. 1 and 2 are a plan and a side elevation respectively of the compressor. The arrangement, it will be seen, nicely balances the work on the two sides of the machine. The first and the third-stage air cylinders are arranged in tandem and driven by one steam cylinder (on the near side in Fig. 1) while on the other side of the balance wheel the second- and fourth-stage air cylinders are driven in tandem by the other steam cylinder. The first-stage air cylinder is approximately 15 in. diam., is double-acting, and is designed to bring the air up to a pressure of 42½ lb. per sq. in. From this cylinder, the air passes to the second-stage double-acting cylinder, of 8½ in. diam., where it is brought to a pressure of 176 lb. per sq. in. The third- and fourth-stage cylinders are both single acting and of 6 in. and 3½ in. diam. respectively. Air leaves the third-stage cylinder at 500 lb. per sq. in. and the fourth stage at 1,470 lb. per sq. in. pressure. The four air cylinders are connected by three intercoolers of ample capacity.

The steam cylinders, on the opposite sides of the crank shaft, are rigidly fastened to the same bedplate as the air cylinders which they drive. They have a diameter of 43½ in. and are equipped with a simple and perfectly balanced piston valve gear. The size of these cylinders is sufficiently great to admit of the engine's running, not only with steam of atmospheric pressure but also with steam having an absolute pressure considerably below that of the atmosphere.

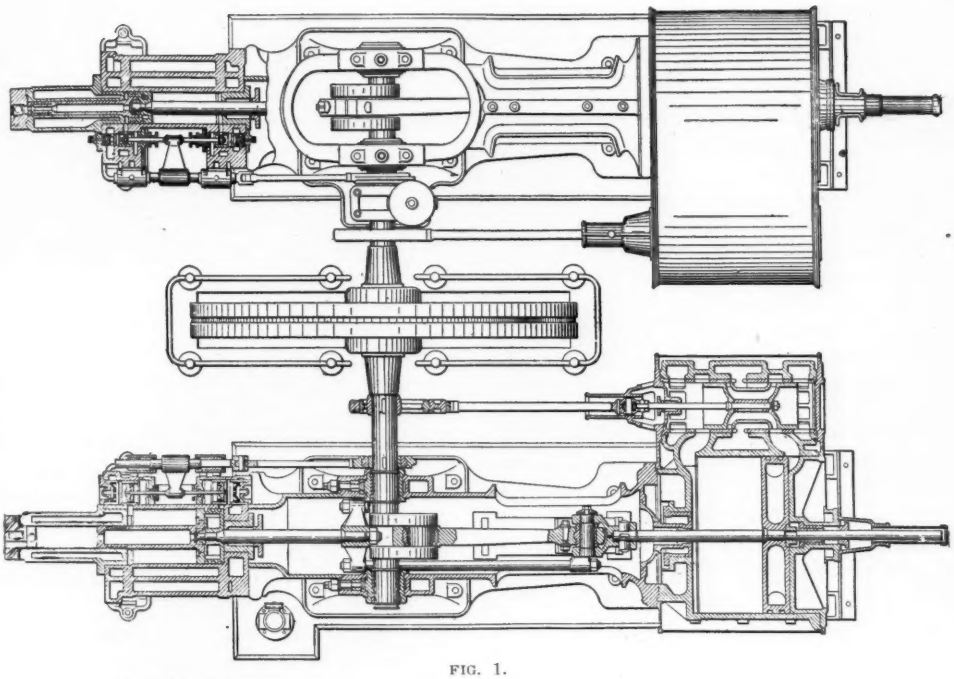


FIG. 1.

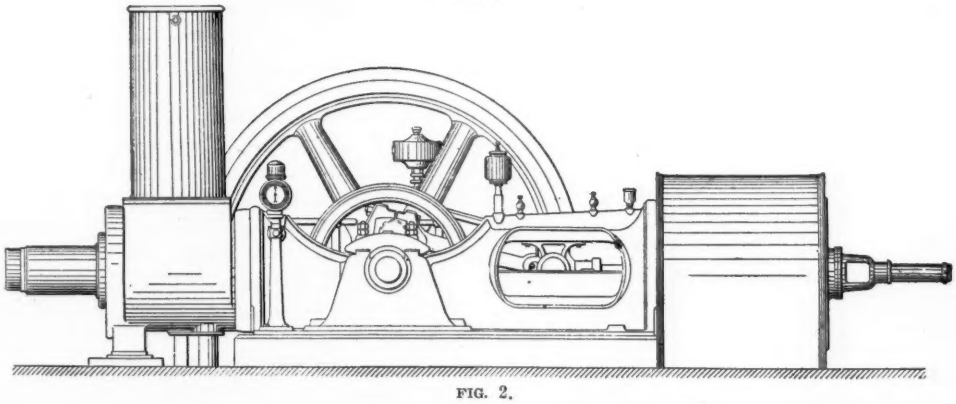


FIG. 2.

In operation, the exhaust steam from the hoisting engines passes through pipes of 24 in. diam. to a heat accumulator, attached to which there is an oil separator with an automatically working discharge. From the accumulator the steam passes directly to the valve chests of the steam cylinders of the compressor. After expansion in these cylinders to about 3 lbs. per sq. in. abs. pres., it is drawn off into a central condensing plant, which maintains a vacuum of about 25.6 in. and is equipped with a piston air pump. The steam cylinders of the compressor are made large enough, as before noted, to work with a pressure as low as 10¼ lb. abs., per sq. in., and thus not only is the usual back pressure of 1½ to 3 pounds absent from the exhaust passages of the hoisting engine, but frequently, after a pause in the hoisting, a vacuum of as much as 6 or 8 in. is found. Therefore, this engine starts more easily, and more quickly gains its highest speed than when exhausting into the atmosphere. As a matter of fact, however, in the actual running of this plant, the foregoing condition of the partial vacuum in the hoisting-engine exhaust is seldom realized be-

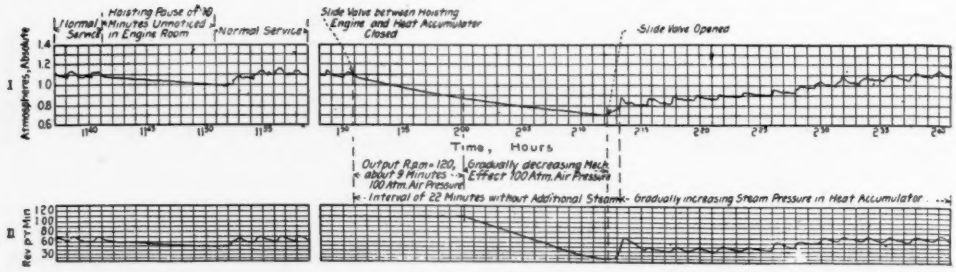

Hoisting Pause of 10 Minutes Unnoticed in Engine Room
Normal Service
Normal Service
Slide Valve between Hoisting Engine and Heat Accumulator Closed
Slide Valve Opened
Atmospheres, Absolute
Time, Hours
Output Ram = 120, about 9 Minutes
Gradually decreasing Mech. Effect 100 Atm. Air Pressure
100 Atm. Air Pressure
Interval of 22 Minutes without Additional Steam
Gradually increasing Steam Pressure in Heat Accumulator
Rev per Min

FIG. 3.

cause this engine gives considerably more steam than the compressor demands and there are comparatively few intervals in the hoisting.

The compressor is kept from running away, in the event of an increasing steam pressure, by an automatic governor valve in the passage from the accumulator to the steam cylinders. This valve throttles the steam and consequently regulates the speed of the compressor engine.

From the diagram, Fig. 3 may be seen to what extent it is possible for the compressor engine to pump out the steam from the accumulator. It will be noted that during a hoisting pause of ten minutes it would be possible for a compressor plant to double the present capacity to run without any appreciable decrease in its output.

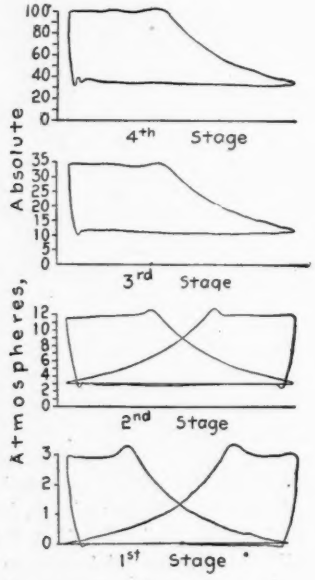


FIG. 4.

An indicator test of the compressor showed that at 120 r. p. m. there was developed in the steam cylinders 195 h. p. which compressed 406 cu. ft. of free air per minute to a pressure of 1,470 lb. per sq. in. This is shown in the indicator diagrams of Figs. 4 and 6. One set of these diagrams has been "Rankinized," Fig. 5, and shows plainly the saving effected by employing four compressor stages. The temperature of the air at delivery was 198 deg. Fahrenheit.

The economy of this installation is apparent from the following considerations: During the normal eight-hour shift, the compressor is run without the admission of any live steam; an increase of the back pressure on the hoisting engine has never been noted and the steam consumption of this engine has not been increased. Therefore, the expense of operating the compressor plant, excepting the item of attendance, is completely covered by the interest and depreciation on the cost of its installation.

The additional first cost for the exhaust-steam compressor plant as compared with an independent live-steam installation is about as follows: Steam piping, $1,199; steam accumulator, $5,236; additional cost of exhaust-steam over live-steam compressor, $1,190; share of expense for larger condenser, $3,094; total, $10,710. Thus, its yearly cost of operation is represented by the interest and depreciation on an additional investment of about $10,710. Allowing 4 per cent. for interest and 10 per cent. for depreciation, this gives:

$$\$10{,}710 \times .14 = \$1{,}500,$$

approximately, as the annual cost.

The annual cost of developing the same horsepower with electric current at $7.14 per 1000 k. w.-hours and figured on a basis of 2400 working days per years would be:

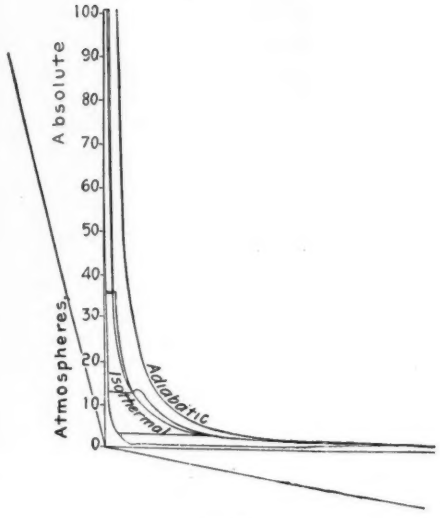


FIG. 5.

$$\frac{195 \times 745 \times 100}{91} \times 0.00714 \times 2400 = \$2741.76.$$

This is assuming an electrical efficieny of 91 per cent.

A live-steam plant with the same out-put would probably require 4840 lb. of steam per hour at 120 lb. gage pressure when operating condensing. Figuring the cost of steam at 21.6 cents per 1000 pounds, this gives $4840 \times \$0.000216 \times 2400 = \$2507.12$ as the cost per year.

At the precent rate of hoisting, the five air locomotives perform daily, in eight hours, approximately 427 ton-miles. Allowing 300 working days to the year, the cost of per ton-mile per day is:

(1) For electrical power, $\$2741.75 \div (300 \times 427) = \$0.02142$;

(2) For live-steam-power, $\$2507,12 \div (300 \times 427) = \$0.01963$;

(3) For exhaust-steam power, $\$1500 \div (300 \times 427) = \$0.0117$.

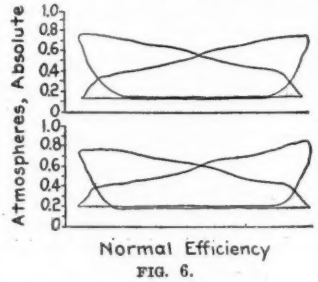


FIG. 6.

This shows that the exhaust-steam power, although not as yet fully utilized, is still cheaper than either live steam or electric energy, and it is expected that this fact will be demonstrated to a much more marked degree when it is possible to run the plant at its full capacity.

OPERATION OF AIR-COMPRESSORS

BY E. A. RIX.

An air-compressor is rated by the displacement of its piston or pistons in single-stage machines, and by its low-pressure piston in two-stage or multi-stage machines. It is self-evident that this is the proper manner, although it is theoretical. Any attempt to give the actual delivery of an air-compressor would give the consideration of many factors, quite difficult to ascertain. It is right, however, for the public to know about this, for when an air-compressor seems unable to do its work or was not large enough in the first place, an intelligent idea of its deficiencies may be helpful in providing a remedy. While an air-compressor does not differ materially from a steam-engine in matters that affect its volumetric efficiency, a steam-engine which is delivering its horse-power is only criticized for its economy, while a compressor, whether economical or not, if it does not deliver the volume, is not doing its work and may therefore have to be replaced. It may be helpful to inquire into the principal things that affect volumetric efficiency, and perhaps among some of them an explanation may be found for the failure of any particular machine under consideration. Insasmuch as single-stage compressors constitute the majority of all air-compressors operated, these may be considered first, and inasmuch as the majority of air-compressors are built for and operated under 100-lb. air-pressure, investigations will be directed to that pressure. The factors affecting the volumetric efficiency are: (1) Piston and valve-pocket clearance; (2) piston and piston-rod leakage; (3) valve leakage and slip; (4) temperature; (5) piston speed.

Piston and Valve-Pocket Clearance.—When the displacement of a compressor is given in terms of the volume swept by the piston, it supposes that there is no clearance of any kind in the cylinder, and that all the air in the

cylinder is forced into the receiver. This, however, cannot be done in practice, for the piston must not reach either cylinder-head by a reasonable distance demanded for safety in operation, and this varies with the character of the compressor. Few builders have less than $^1/_{16}$ in., and many ¼; an average may be safely taken as ⅛ inch.

When compressing air to a given receiver pressure, it always takes a higher pressure within the cylinder than is indicated in the air-receiver; this is due to the power required to force the air through the valve passages. At 100-lb. receiver pressure, the pressure remaining in the clearance space is at least 5 lb. greater, or 105 lb., which corresponds to eight atmospheres or eight compressions. The ⅛ in. of clearance, then, is filled with air at 105-lb. pressure. Now, when the piston begins its intake stroke it is evident that, until the compressed air in the clearance space expands to atmospheric pressure, no air can come in from the atmosphere. An eighth of an inch clearance would thus hold compressed air enough at 105 lb. to expand to one inch before any air came into the cylinder. In other words, the stroke has been actually shortened one inch. It is evident, therefore, that the shorter the stroke with the same clearance, the less the volumetric efficiency; a 16-in. stoke losing 6 per cent., an 8-in. stroke losing 12 percent., and a 4-in. stroke 24 per cent. It might not be supposed that anyone would operate a 4-in. stroke machine with any such clearance as ⅛ in., but I have seen a ⅛-in. gasket put under the heads of a 4-in. stroke compressor that already had $^1/_{16}$-in. clearance, making $^3/_{16}$-in. clearance; and this simply because a gasket of that size was on hand. It was therefore used, the result being that the compressor doctor had to be called in.

Now, in addition to the piston clearance, there are the pockets below the outlet and inlet valves that add to the other clearance. Generally speaking, this is about one-fourth of the piston clearance. Taking both these clearances into consideration and reducing them to percentage of cylinder volume, it may be said that the average single-stage compressor has clearance spaces equal to 2 per cent. of its volume. At 100-lb. receiver pressure, therefore, which calls for eight expansions in the clearance, there is a direct loss of volume by clearance of 16 per cent. in the average single-stage machine.

Piston and Piston-Rod Leakage.—No piston is ever tight in an air-compressor, even when it is new and fitted with the best of rings; neither can this be expected, for it requires gaskets and many bolts to keep a cylinder-head tight, and heavy pressure from a long wrench to make a pipe-thread tight. It is evident, therefore, that the contact the rings make with the cylinder walls is not sufficient for a joint. This can easily be tried by taking an inlet-valve out of one end of an air-compressor and an outlet-valve from the other end; admit the receiver pressure at 100 lb. into the cylinder, and the air will rush out through the inlet-valve opening in proportion to the condition of the cylinder piston and rings. Inasmuch as sometimes this becomes a great loss in an air-compressor, an operator should, upon installing a compressor, make the above test to familiarize himself with the normal leakage when the compressor is new. Then, when the machine is not delivering its proper quantity, a second test will show the difference. For this purpose I use a plug to screw into the inlet-valve opening. This plug has a round hole bored in it of such a size for any given compressor that the pressure indicated on a gauge also attached to the plug shows somewhere from 2 to 10 lb. By a reference to a "Discharge from Orifices" table, the approximate volume flowing out may be determined and recorded. If after use this machine requires overhauling, a repetition of this test will show the additional comparative loss, and thus the condition of piston and rings may be determined without removing them. Speaking of rings, it is seldom that snap rings, even with eccentric circumferences, are good enough for compressors having cylinders over 8 inches diameter. Sectional rings provided with springs are better.

The leakage around the piston-rod through the packing gland may be considerable when a compressor is carelessly operated, or it may be practically nothing with good packing, a smooth rod, and proper attention. Taking average cases, it may be assumed that there is a general loss of 3 per cent. of the volume of the cylinder due to leakage around the piston and piston-rod. In testing for such leakage the piston is placed in different positions and air under pressure that corresponds to the

position of the piston is admitted, and the results are then properly averaged.

Valve Leakage and Slippage. — Poppet valves are seldom perfectly tight, and at ordinary operating speeds do not close exactly at the end of the piston stroke. All resulting leakages are against the volumetric efficiency of the compressor. In the inlet-valve comes, first, the slight slippage due to delayed closing when some of the air in the cylinder will be pushed out again; and when the valve is seated, if it is not absolutely tight, a certain quantity is being pushed out as compression progresses. In the outlet-valve the slippage and leak help fill the cylinder as the intake stroke progresses, thus reducing the intake volume. I determine these leakages in the same manner as with the piston leakage, by means of a pressure gauge and small nozzles, using the orifice discharge tables to get the quantity. In ordinary machines these valve leaks and slippages will amount to 4 per cent. of the cylinder volume. It will readily be seen that the slippage is a function of the piston speed; the greater the speed the greater the slippage, until a speed of 200 r. p. m. is attained, which is practically the limit for ordinary poppet valves. Indeed it may be less, depending on the weight of the valves. I remember trying a 10 by 10 compressor driven by a water-wheel so that any desired rate of revolution could be maintained. A hole was drilled in the side of a receiver and gauge reading taken at various speeds. At 168 r. p. m. the maximum reading was taken, and this reading was maintained up to 180 r. p. m., when the pressure fell for any increased number of revolutions. If mechanical valves had been used the revolutions could have been materially increased; just what the limit would be, I do not know.

Temperature Considerations.—These are of great importance and are extremely difficult to determine. It is evident, however, that the lower the intake temperature is, the greater the weight and consequently volume of air the compressor will deliver. It is desirable, therefore, to draw the air from the coolest place adjacent to the machine, and at the same time from a place free from fume or dust. It is also evident that the hotter the inlet-valves, the more heated the intake air becomes in passing through and over their hot surface, and the greater it will expand, thus reducing the weight taken into the cylinder and consequently the resultant volume of compressed air. The same is true of heated cylinder walls and heads. Inasmuch as water-jacketing is the only method in a single-stage compressor for reducing these temperatures, it is important to see that the water-jackets are free from sediment and that a quantity of water is passed through the jackets sufficient to show no noticeable difference of temperature in passing through. The idea is to keep a cylinder cool in order to get as great a weight of air as possible into it.

An experiment can readily be made to show this temperature influence. Drill a hole in the air-receiver and note the gauge pressure when it becomes stationary with the compressor running, then close off the jacket water and note the pressure gradually drop, showing the loss of volume. In average single-stage machins, 7 per cent. is not too much to allow for losses due to temperature influences.

Summing the losses, they are: (1) Clearance losses, 16 per cent.; (2) piston and rod losses, 3 per cent.; (3) valve leakage and slippage, 4 per cent.; (4) temperature losses, 7 per cent.; making a total of 30 per cent. In other words, the compressor gives 70 per cent. of its catalogue free-air rating, when operating at catalogue speed and 100-lb. receiver pressure. This seems quite a loss, but it is practically true, and may be considered inherent in the ordinary poppet-valve single-stage compressor. Now, if this condition exists to start with, and never grows better, but always worse by wear, it is evident that the best care and attention must be given the machine. I have noted many machines of this type that were not giving 50 per cent. volumetric efficiency from being in bad repair and unskillfully handled. It becomes evident, therefore, that if an air-compressor is not doing its work, very material gains can be made by investigating the sources of loss as herein indicated, and making necessary repairs. It is also self-evident that these losses will decrease in some ratio as the pressure decreases, and by experiment the result is about as follows:

Volumetric efficiency at 100-lb. pressure, 70 per cent.; at 80 lb., 77 per cent.; at 60 lb., 82

per cent.; at 40 lb., 85 per cent.; at 25 lb., 88 per cent. In other words, the same compressor will give 25 per cent. more air at 25 lb. than at 100-lb. receiver pressure. Now, inasmuch as 25 lb. is the working pressure of the low-pressure or intake cylinder in a two-stage machine, it needs no comment to show why it is desirable. It is also evident that a purchaser is getting 25 per cent. more for his money, independently of other gains, when buying a two-stage compressor.

While compressors are rated by displacement which does not show their true output, most pneumatic tools are very much underrated by their builders, especially pneumatic riveters, chippers, and boring machine; some as much as 50 per cent. An air-compressor need not be condemned for lack of duty, therefore, if it does not operate as many tools as rated in the catalogue.

For first aid for a crippled compressor, it may be suggested that excessive piston clearance may be remedied by putting a thin piece of boiler plate on the piston, or thin paper gaskets under the heads, if possible. Piston and rod losses point to re-boring the cylinder, to new rings, and to need of proper packing. Valve leakage demands re-grinding; valve slippage, the putting in of heavier springs and re-grinding, and, if revolutions of the compressor are excessive, these must be reduced. Temperature losses may be decreased by giving cooler inlet air, cooler jacket water or more of it, or by cleaning out the jackets. If a compressor lacks but a small percentage of furnishing air enough for its work, and the preceding suggestions have all been taken advantage of, then a "booster" consisting of a rotary blower may be attached to the suction of the compressor so as to give an intake pressur of one or two pounds, and this will materially increase the output of the compressor. Care must be taken to supply a blower having at least 15 per cent. greater capacity than the compressor.—*Mining and Scientific Press.*

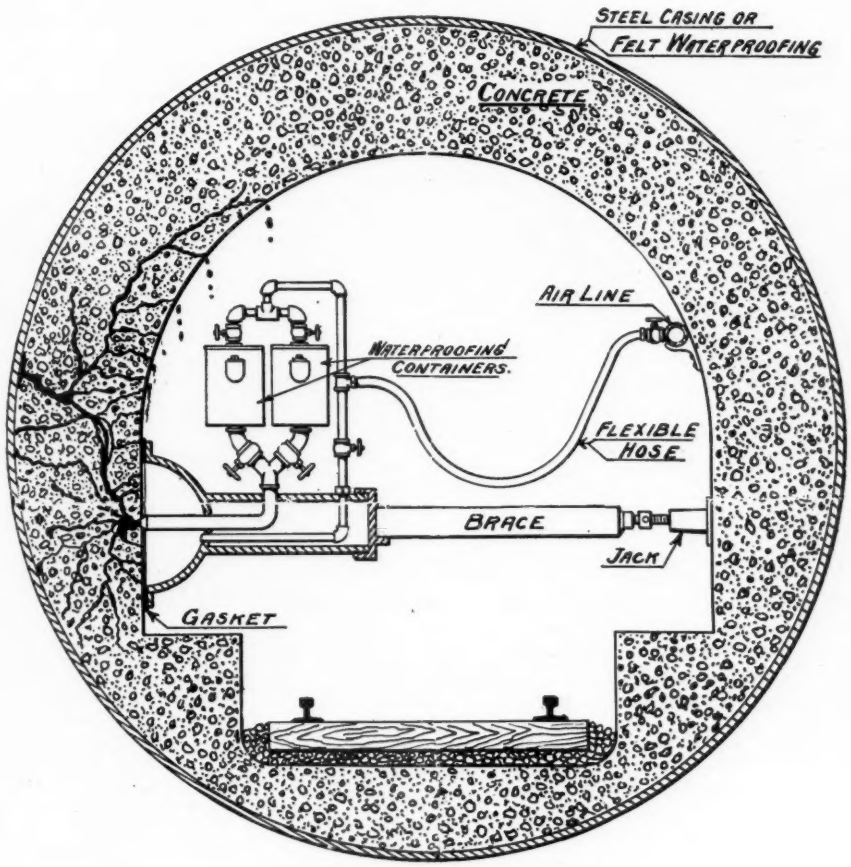
The passing winter has been so cold as to freeze up and stop the Grand Trunk Pacific passes to members of the Saskatchewan legislature.

A SCOTCH MIST ATMOSPHERE FOR SOUTH AFRICAN MINES

Consolidated Gold Fields of South Africa is really a remarkable enterprise, or, at all events, those gentlemen are remarkable who are responsible for its management. To what other body of men would it have occurred to introduce a "Scotch mist" atmosphere to purify the underground workings of the Rand mines? A Scotch mist atmosphere is to be introduced into the workings during the night, and, then, when the day shift resumes duty, a sort of heather smell will render the stopes and drives "cool and pleasant to work in." At this rate, the underground workings of the Rand mines may become a health resort, but while the Consolidated Gold Fields authorities are about it, why do they not try the effect of a London fog? This reminds us of the complaints made of the atmosphere of the Metropolitan Railway's tunnels before electrification days. A former chairman of the company was determined to stop this sort of thing and engaged a learned professor to analyse the tunnel air. But even the chairman in question felt that the professor had gone too far when he reported that the air in the tunnel at Gower street reminded him of nothing so much as that he inhaled on a Scotch moor!—*Mining World,* London.

STEEL WORKS MUST SMOKE

In an address before the Sheffield Electro-Metallurgical Society Prof. J. O. Arnold took occasion to censure the smoke-abatement movement and to point out that without smoke steel is impossible. So far as health is concerned, he said, the most mischief is caused by the household smoke, yet it is usually ignored by the smoke inspectors. Strange as it may seem, some medical men have recently taken to recommending the smoky parts of Sheffield for sufferers from asthma. Prof. Arnold asserted that in steel metallurgy smoke is absolutely necessary. Any operation that removes the carbon will produce poor steel. If a smokeless flame is used all the carbon is burnt out and the surface of the steel is made rotten. Most magistrates realize that smoke is essential to the manufacture of good steel and exempt metallurgical furnaces, but the question of mixed stacks is continually coming up to the annoyance of manufacturers.



MOORE WATERPROOFING APPLIANCE.

WATERPROOFING AGAINST PRESSURE

The accompanying sketch shows quite clearly the operation of a device which is being successfully employed for filling cracks and stopping leakages in concreted tunnels which are subject to external water pressure. Minute cracks or larger unfilled crevices extending entirely through the material seem to inevitably occur in the most carefully concreted subaqueous tunnels, these being either found at once upon the completion of the work or developing later in consequence of natural shrinkage or from the jar and strain of heavy traffic. The resulting inflow of water is a constant source of annoyance and expense, and if not quickly remedied results in delay or stoppage.

On account of the water pressure, leakage of this character can never be stopped by the application of paints or cements upon the exposed surfaces, as they are washed away as soon as applied. The water which is flowing through the cracks must first be driven back and the space it occupies must be filled with the waterproofing material, and this material must have the property of adhering where it is placed and of immediately assuming a permanent hardness, thus making it not only a filling but also a binding or strengthening material. The Mica Paint employed in connection with the apparatus has been demonstrated to completely satisfy all these requirements, and without it, or some equivalent if discovered, the operation could not be a success.

Referring to the cut, which is to be regarded as a sketch only, and not suggestive of actual dimensions or of the details of practical ap-

plication, a large cast iron bowl is placed over the crevice to be stopped and made as air-tight as possible by a thick, yielding gasket against the cement surface, with the brace and screwjack behind it to resist the pressure. Compressed air is then turned on sufficient to drive back the water, and the mica paint is then admitted to the bowl and, backed by the air pressure, is driven in to fill the cracks. When one crack, or a portion of it, has thus been treated the bowl or air tight chamber is placed to cover another crack, and so on until all the leakage has been permanently cured.

This is beyond the stage of experiment and is a demonstrated success, having been employed upon the Hudson River tunnels of the Pennsylvania Railroad and elsewhere with most satisfactory results. The operation as described seems simple enough, but in the practical employment of it of course judgment and experience count for much, and especially does the success of it depend upon the use of a filling material which completely satisfies the imperative rquirements. The Mica paint, as a paint, has been thoroughly tried by the paint experts of the New York Central, Baltimore & Ohio, Pennsylvania Railroad and the American Car & Foundry Company for steel cars. Both the apparatus and the paint are controlled by The Mica Paint Company, 76 William Sstreet, New York.

AIR BLAST FOR CHILLS IN FOUNDRY

Details have recently been made public of a new method of making chilled rolls for sheet and tin plate mills, in which the chilling is done by air blast instead of by water. The chilling section of the mold is surrounded by a drum having a spiral internal fin. Air under pressure is fed into this drum and, after circulating in a spiral course around the mold, is exhausted to the atmosphere. The mold is ribbed, radiator fashion, to facilitate cooling. The operator can control the cooling effect at will by manipulating a gate valve where the blast enters the mold, and a thermometer fixed in the flow of the blast as it leaves the drum indicates exactly how the cooling is proceeding. It is claimed that the process not only produces a perfectly even chill, but a surface is given to a sheet or tin plate roll which is practically the same as that given by the water-chilling process and without the risk of internal stresses in the metal. The time of cooling is absolutely within the power of the operator, so that the metal can be set rapidly to get the necessary polish for the face and then the body be cooled gradually to eliminate the casting stresses. Other advantages claimed are simplicity, an even depth of chill, and the absence of wave marks on the finished sheets.

It is not generally known that in many of the bituminous mining districts of this country fully 50 per cent. of the coal in an acre is left in the ground, with no possible hope of ever being recovered.

The largest coal contract ever awarded an operator in the Virginia field has been given the Virginia Iron, Coal & Coke Co. by the Boston and Maine railroad. It is the railroad's coal contract for five years, and involves nearly $10,000,000.

In the Canal zone the following warning notice has been posted: "Alcohol, gasoline, benzine, naptha or kerosene are easily ignited. They must be kept in a cool, well ventilated place, remote from lights or fires. Lamps or burners must never be filled while lighted. The pouring of any of these fluids on a lighted fire or live coals, or on inflammable substances which it is the purpose to ignite, is dangerous to life and is absolutely prohibited."

NEW YORK FOUNDATION METHODS FOR MICHIGAN MINE SHAFTS

BY P. B. MC DONALD.

The sinking of concrete drop-shafts, using compressed air for holding back water and quicksand, was introduced by the Cleveland-Cliffs Iron Co., some four years ago, for several shafts on the Swanzy range south of Negaunee, Michigan. Attention has been attracted to the process by the success attained by its use in bridge-pier and tunnel work. The method has since been utilized a number of times, both on the Michigan and Minnesota ranges, and its adoption has followed the growing tendency toward exploration of deep, drift-covered deposits by churn and diamond-drilling. Ore-bodies discovered under heavy overburden by drilling, demand permanent,

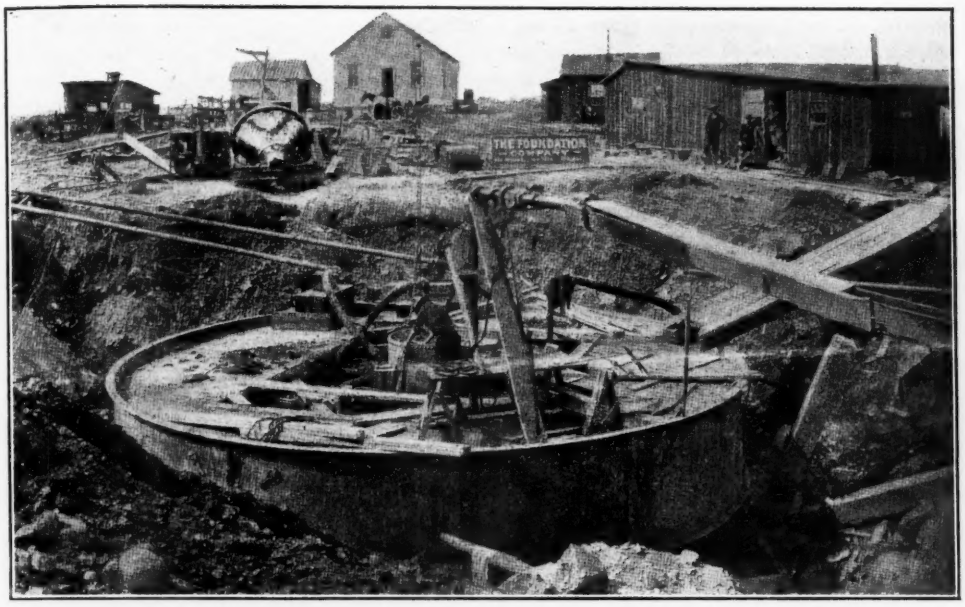


FIG. 1.

water-tight shafts for hoisting purposes, and the recent impetus given to diamond-drilling has encouraged the practice of sinking concrete shafts.

The Munro Iron Mining Co. had proved a large orebody by diamond-drilling at the Rogers mine, four miles east of Iron River, and it was desired to sink a shaft in the foot-wall through 140 ft. of glacial gravel, sand, quicksand, and boulders. None of the operating mines of the district are within three miles of the site chosen, so that the overburden gave promise of containing considerable water, especially as a swamp overlies a portion of the orebody.

A timber shaft might have been attempted, but it was known that a mine nearby had been trying to put down a timber shaft for over a year and was finding it difficult. Also, when finished, a timber shaft would let in a large quantity of water and might give trouble as to keeping it plumb. Thus the Maas timber shaft on the Marquette range got out of line so badly, and let in so much water, that after several years' use it was filled with sand and a large concrete shaft was sunk around it. Teal lake, not far distant, from which the city of Negaunee gets it water supply, had begun to lower materially, so that it was thought the lake was draining into the Maas mine. Since the concrete shaft was finished the level of the lake has risen.

It is to be understood that it is the thick overburden, with its tendency to shift and conduct large quantities of water, that presents the most difficult part of sinking and maintaining shafts in the Lake Superior region. The portion of a shaft which is in solid rock makes comparatively easy sinking as compared with work in wet soil, where the excavation is constantly getting out of plumb, and water and quicksand come in in such quantity as sometimes to compel abandonment of the work.

For this reason a concrete shaft is very satisfactory in such a place if the ore-body warrants the initial cost. The Roger's shaft here spoken of cost approximately $500 per foot; a timber shaft might have been cheaper, or it might have cost more.

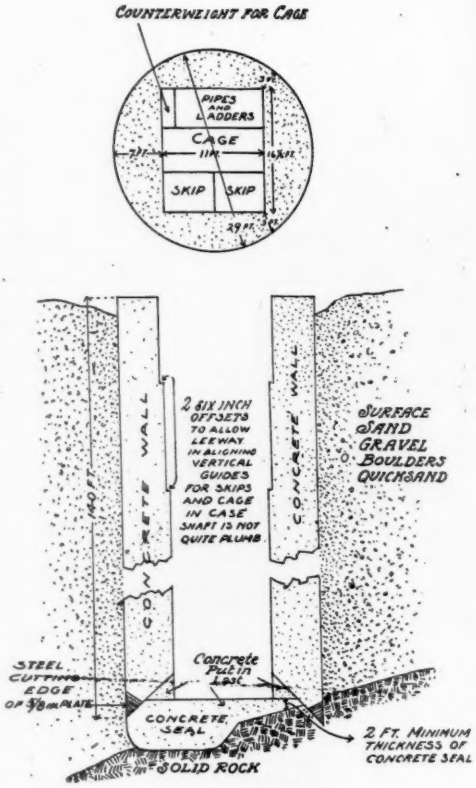
The work of sinking the concrete drop-shaft through the 140 feet of overburden was undertaken by the Foundation Company of New York. Work was begun about the middle of February, 1911, and the drop-shaft was sealed to the rock about the middle of July. Three months of the time was spent on the first 125 ft., during which no compressed air was used,

and two months on the last 15 ft., with compressed air at a pressure of from 38 to 45 pounds per square inch as the sinking reached the rock. In the heaviest pressures each man worked two 40 minute shifts per 24 hours and received $4 per day.

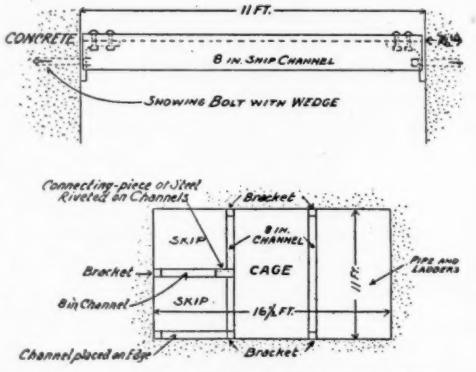
The first stage of the work, with no compressed air, went along rapidly and consisted simply of dredging dirt with a clam-shell and derrick from the interior of the shaft, so that the concrete casing sank by its own weight, more concrete being added at the surface in 5 ft. sections as needed. During these three months the shaft was kept full of water (to the level of ground-water, about 30 ft. from the surface) which helped work the dirt from under the cutting edge of the casing, so that the clam-shells could work to better advantage. The bottom or cutting edge of the shaft was sharply beveled and encased in a steel plate for the better forcing of its way through the overburden. The weight of the heavy concrete walls was sufficient to drive the shaft down as the earth was dredged out from the interior. Vertical and horizontal reinforcements were used in the concrete, both of 1 in. steel, and placed near the outside and inside edges, about 18 in. apart.

The second stage of the work, with compressed air, held in the shaft by a 6 ft. timber and concrete deck placed across the opening, was made necessary because boulders and hardpan were encountered, requiring men to work with pick and shovel under the cutting edge. The deck was set in notches left in the concrete, and the men and earth were "locked" in and out through a cylindrical steel chamber placed over a hole cut in the deck. Men used to this special work were brought in, about half of whom were negroes. It was estimated that the lifting pressure under the deck was about 700 tons. The deck and air lock were put in with considerable care and an air compressor of reliable type, the so-called *Hurrican Inlet* pattern was adopted.

When the rock was reached it was necessary to cut out the soft, oxidized upper layer in order to seal the shaft to hard, compact rock. When this was finally done the Foundation Company's contract was finished and the air pressure was taken off. The shaft had to be delivered by them water-tight, ready for the mining company to begin sinking with rock drills, and unless the bottom had been properly sealed to firm foundation the shaft would not be water tight in the bottom. No water had been pumped, so that the level of ground-water of the surrounding country was unchanged, and about 100 ft. head of water was on the shaft. In this respect the method



PLAN AND SECTION OF DROP-SHAFT.



CROSS-SECTION OF SHAFT. DIVIDER SHOWN ABOVE.

FIG. 2.

is markedly different from ordinary sinking, in which the level of ground-water is lowered by the pumping necessary to enable men to work in the shaft. With the compressed-air method, instead of seeking to drain the surrounding country and lower the level of ground-water, the water is held back by air of a pressure in pounds per square inch approximately of one-half the number of feet head of water outside. When the casing has been bottomed in solid ground and sinking in rock is commenced, the water can be pumped to better advantage, as it cannot come in so fast. However, the soft rock must be removed from the rock surface while the air is still on, or otherwise the miners will be drowned out by a rush of water when drilling is commenced in rock.

Putting in the steel dividers after the casing had been sealed to rock was a job requiring careful attention. In the first place, despite the two 6-in. offsets, one wall of the shaft had to be chipped off considerably to use 8-in. ship channels for drivers and to support them on steel brackets. To fasten the brackets to the walls, two holes were drilled with an air-hammer drill and the bracket bolted with two bolts, which were driven in on wedges to expand their ends; melted lead was then poured into the holes to make a firm joint. Condensed from *Mining and Scientific Press.*

DUST EXPLOSIONS

While powdered coal has almost alone been the subject of recent investigations, it cannot be too plainly insisted upon that all finely divided, highly carbonaceous material possesses dangerously explosive potentialities. In May, 1878, a tremendous explosion occured in the Washburn Flour Mills at Minneapolis. The building was completely wrecked. Subsequent investigation led to the opinion that the flour dust was the primary cause of the disaster. Some time ago a similar explosion occurred in a Manchester starch factory. On the 10th of last November an explosion occurred in Messrs. Primrose's flour mills at Glasgow, as a result of which five persons were killed and eight injured. At the inquiry held on the disaster it was stated that there was evidence to show that the explosion had been due to the ignition of meal dust by a naked Bunsen burner. It appears that at half-past five each night it was customary to sweep up the accumulation of dust from the floors. The explosion occurred at half-past six. It should also be recorded that at the inquest held in connection with the explosion which occurred at Messrs. Bibby's oil cake mill at Liverpool on November 24th, it was stated that tests showed the dust in the mill to be equally, if not more, explosive than coal dust.

OXYGEN STRETCHER

In rescue work after a coal-mine explosion it not infrequently happens that a man is found, unconscious but still breathing, beyond a stretch of bad air. Could the man so overcome be safely brought to daylight, in many cases his life might be saved by the application of a pulmotor, or some similar device. In order to carry a helpless patient through bad air D. H. Reese, foreman in charge of the instruction car of the Victor-American Fuel Co., Hastings, Colo., uses a combination of an ordinary stretcher with the standard form of oxygen apparatus which has proved very effective whenever tried.

The outfit consists of a stretcher of extra heavy canvas to which is fastened a complete set of Westphalia oxygen apparatus, in the position shown in the half-tone here reproduced from *Mines and Minerals.* The oxygen tank rests in a steel bracket fastened to the bottom of the stretcher, and when empty may be replaced in a few seconds. The indicator,

reducing valve, breathing bag, hose, etc., are all of the standard pattern and interchangeable with similar parts used by the regular rescue crews. The face mask is fastened on with double straps. It will be noted that straps are provided to securely fasten the patient upon the stretcher in event of his having to be carried over falls or the apparatus has to be "up ended" when placed on a cage. The breast strap is 3 feet long and 2 inches wide; that over the hands, 5 feet long and 1 inch wide, and the abdominal and leg straps each 3 feet long and 1 inch wide.

In actual practice it is found possible to have an unconscious patient breathing oxygen within 1 minute of his discovery, and strapped upon the stretcher within 4 minutes more. The entire apparatus as used by Mr. Reese weighs 42 pounds.

GAS FOR MELTING GOLD AND SILVER

As a result of experiments which have been made since 1909, the British Royal mint has adopted gas as a fuel for its melting furnaces. The adoption of gas as a fuel in place of coke has been accompanied by several incidental economies. The charge for fuel averages about 4½d per hundredweight of standard gold bullion as against 9d when coke was used. The fuel needed to warm up the furnace in the morning has been eliminated; but, including this, the cost rarely exceeds 5d per hundredweight on a day's work. During 1910 the mint installed sixteen gas-heated furnaces, each capable of taking a 400-pound crucible. These 16 crucibles have a maximum capacity of 2¾ tons of silver, or 2¼ tons of bronze per melt. Five furnaces similarly gas-heated, but of smaller size, are used for melting gold. The expenditure on crucibles, which is a large item, has been reduced by 33 per cent.

TESTING CYLINDER OILS

1. Saponification test. 2. To ascertain if there is any free sulphuric acid in mineral oil. 3. Flash tests. 4. Burning test. 5. Precipitation test. 6. Congealing test. 7. Test for acids. 8. Test for alkalies. 9. For viscosity.

1. Place a small quantity of the oil in a pan of some kind, and put into the oil about 2 ounces of concentrated lye. Boil the oil for about 30 minutes and then let it cool off. After the oil is cool examine the surface, and if it is covered with a soapy substance it contains fatty matter. If the surface is clear, it is mineral oil unadulterated.

2. Take a small quantity of the oil to be tested and heat it in a pan or other convenient vessel, to about 300 deg. F. Let it stand for a few minutes, and then let it cool off. If the oil is darker in color than before boiling, it is fair to assume that there is sulphuric acid in it. Oil containing sulphuric acid should not be used for lubricating the internal parts of steam cylinders and valves.

3. Heat a small quantity of oil in a vessel to about 300 deg. F., to begin with. Light a piece of stick and pass it over the surface of the oil, back and forth, until the vapor from the oil takes fire with a flash, the temperature at which flash occurs is called the flashing point.

4. Continue to heat the oil until a lighted stick passed over the surface causes it to burn, the burning point is then reached, the temperature being indicated by the thermometer.

5. Place about an ounce of oil in a bottle, say of about ½ pint capacity. Then pour in about 2 ounces of gasoline. Shake up the oil and gasoline thoroughly, and allow the bottle to stand long enough for the contents to settle. If there is any sediment in the bottle, the oil has been doctored.

6. Pour out some oil in a pan, and place the pan in a quantity of ice to which salt has been added. Cover the pan with something to exclude the warm air of the room. In a short time the oil will congeal; next surround the pan of oil with boiling hot water, until the oil begins to melt, at which time the immersion of a thermometer will indicate the congealing point of that particular sample of oil.

7-8. Take a small quantity of oil and place in a vessel of boiling water, say about an ounce of oil to six times its volume of water. Also steep in the water a piece of red litmus paper. After the whole has soaked for a while, if the litmus paper remains red, the oil contains acid. If the paper turns to full blue, the oil is alkali. If the color of the paper changes slowly to a light blue, the oil is neutral.

9. Take a sheet of glass and make an inclined plane of it by blocking up one end. Place a drop of several oils at the top edge of the glass, and note just how fast each drop runs down the plane toward the bottom. That which gets to the bottom last, is the highest in viscosity.—*Practical Engineer.*

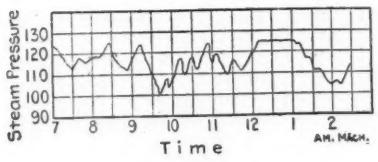


FIG. 1

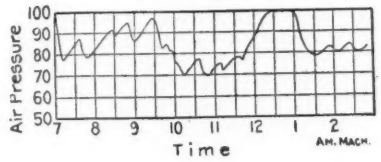


FIG. 2

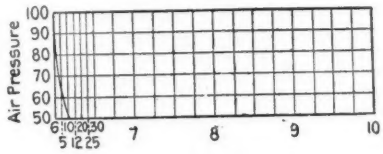


FIG. 3

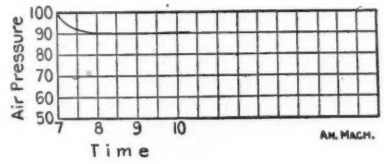


FIG. 4

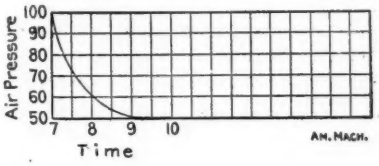


FIG. 5

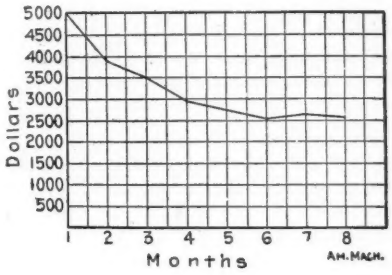


FIG. 6

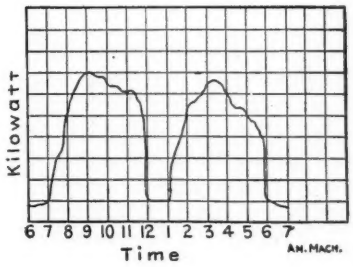


FIG. 7

LOCATING AND CORRECTING POWER PLANT INEFFICIENCIES*

BY C. J. MORRISON.

In an ordinary shop of the present day the arteries, as you may call them, carry steam, compressed air, water and electricity. Recording gages, placed on these arteries, will reveal an interesting story. In one shop the records showed immediately that the variations at the power house materially reduced the efficiency of the plant and, at the same time, gave the information that the machines were not producing the maximum possible output.

The steam gage gave an average record, as shown in Fig. 1. The air record was even worse, as revealed by Fig. 2. With all valves closed and the compressors shut down, the record in Fig 3 was obtained. With all valves closed and one compressor, which gave one-third of the total capacity, running at full speed, Fig 4 was recorded.

Translated: One-third of the entire power of the compressors was being exerted to hold a 90-lb. pressure against leaks in the line. A still further loss was due to moisture in the air. The installation of cooling and reheating tanks and the appointment of a man to stop the leaks, soon overcame the difficulty with the air, so that a month later Fig. 5 was obtained, with all valves closed and the compressors shut down.

The air-trouble man was paid a bonus, depending on the leakage, and soon got the pipes in such condition that the pressure did not drop below 50 lb. at the end of a five-hour shutdown. As the fluctuations in steam pressure were felt to be at the bottom of the difficulty, steps were taken to effect a cure. An automatic draft regulator was installed, and a change made in the grates. These improve-

*Condensed from *American Machinist.*

ments not only gave a steady steam pressure, but reduced the power-plant expenses, as shown in Fig. 6.

The consumption of electric power for the entire shop, revealing a low efficiency, is shown in Fig. 7. It was at once evident that many of the machines were not started until long after the starting time, and also that many were stopped before time. These records were obtained for each department, and the superintendent went vigorously to work to secure square records. Any foreman whose department was not producing a square record was called upon for an explanation, with the result that at the end of the second month the plant was showing a 10 per cent. increase in output.

This desirable result was obtained with no change in, or disruption of the organization, and the money expended was almost immediately returned by the reduction in power-plant expenses.

CHEAP AND EFFICIENT WATER COOLING

The illustrations here reproduced from *Gas and Oil Power,* London, show us the Tattersall patent rapid, multiple effect water cooler, made by C. Whittaker & Co., Haslingden, England. Its action is based upon two familiar facts which science has established. The first is that when water is evaporated a large amount of heat is absorbed by the water vapor and becomes latent, this latent heat being absorbed from the water, and the matter with which the water is in contact, and cooling it to that extent. When 1 lb. of water at 60 degrees Fahr. is evaporated, approximately 1,100 British thermal units are absorbed, in this case from the rotary evaporators, cooling them and the air. The second fact is that the higher the temperature of the air and the lower its degree of saturation, the greater is its power of evaporation.

In this cooler advantage is taken of these facts to the fullest extent, which enables it to evaporate a much larger quantity of water and to produce a greater cooling effect than other coolers which operate only with air at normal temperatures and discharge it cold and more or less saturated.

The cooler occupies small space and requires little power to drive it. It consists essentially of a series of rotary evaporators

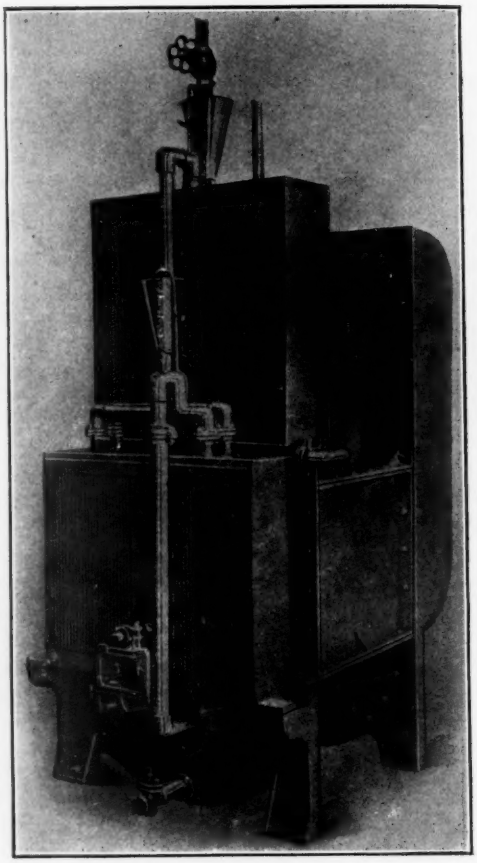


FIG. 1.

formed of a large number of short tubes of small diameter, each of which carries up a definite quantity of water which is evaporated by the air passed through and between the tubes. The lower parts of these evaporators pass through a tank containing the water to be cooled, and from this they continually abstract heat. There are two radiator batteries of high efficiency formed of flat tubes arranged one above the other, through the tubes of which the water to be cooled successively passes before entering the tank, and between the tubes of which a current of air passes, thus securing a transference of heat between the two whereby the water is cooled and the air heated. Other parts of the cooler include a fan to produce the current of air, a pump to circulate the water to be cooled, a ball tap to admit water to make up for that carried off in the air by evaporation; the necessary cas-

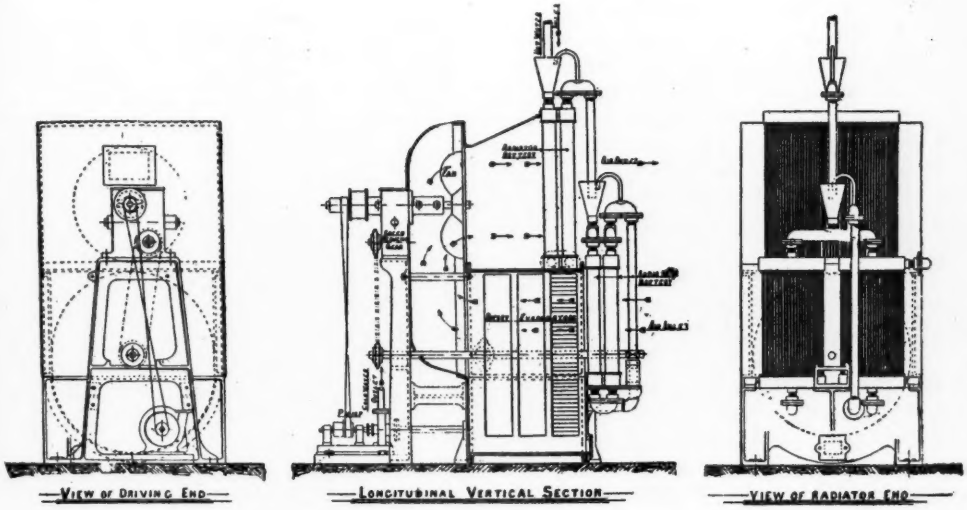


FIG. 2.

ings and supports, and the driving arrangement.

In operation the fan draws air, as indicated by the arrows, through the bottom radiator battery, where it cools the water passing through the battery, and becomes heated, whereby it is enabled to absorb and evaporate a much greater quantity of water from the rotary evaporators through which it next passes; in doing which it cools the evaporators and is itself cooled, and is then forced by the fan through tne top radiator battery, where it absorbs heat from the water passing through and becomes heated, in which state it is discharged from the apparatus. It will thus be seen that the water passed through this cooler gets a triple cooling effect, viz.:—first, in the top battery, and, secondly, in the bottom battery, thus receiving a preliminary cooling before reaching the tank which it enters at a greatly reduced temperature, one effect of which is to prevent vapour being given off. The third and final cooling is in the tank by means of the rotary evaporators, as explained previously. No water or vapour is carried out into the air and wasted, only hot dry air being discharged, and this, of course, itself may be used for ventilating or drying.

We are informed that practical results bear out the theoretical economies claimed. In use a cooler of the type illustrated, the overall dimensions of which are 6 ft. long, 3 ft. 6 ins. wide, and 6 ft. 6 ins. high, passed 4,000 lbs. (= 400 gallons) of water per hour, and reduced the temperature from 134 degrees Fahr. to 78 degrees Fahr. = 56 degrees Fahr., which equals a cooling effect of 224,000 B. T. U., and assuming that in a gas or oil engine each H. P. requires 3 gallons per hour to cool the circulating water from, say 120 degrees to 80 degrees Fahr. = 40 degrees Fahr., then this plant would cool an engine of 250 H. P. In this case the tests were made during January, 1912, under very bad conditions, the temperature of the air before entering the cooler being 58 degrees Fahr. dry bulb, and 56 degrees Fahr. wet bulb, the saturation being 87 per cent., and the evaporative efficiency of the air only .7 of a grain of water per cubic foot of air. The air left the cooler at 87 degrees Fahr. dry bulb, and 76 per cent. Fahr. wet bulb, the saturation being 55 per cent. The power to drive the cooler was slightly over 2 H. P., or less than 1 per cent. of the engine power.

THE ANTETYPE OF THE ROCK DRILL

The first and most perfect drill instrument of its kind is still in use. In fact, more of these drills are used than of all other makes put together. The drill has few parts and the simplicity of its mechanism is one of its advantages. Its main feature consists of three long pieces which are dovetailed one with another, and glide easily through their entire length, the boring being accomplished by the

alternate gouging of the chiseled tips. Two of these parts act as guides which close about the drill proper. This drill is not adapted for work in hard material but for all that those who have used it prefer it to any other type on the market. This drill is controlled by a bug, whose nickname is *Thalessa Lunator,* or in plain United States, the great ichneumon fly. Its boring mechanism is said to have furnished the idea for the modern rock drill.

REDUCING THE DANGER OF SEA DIVING

The writer had an opportunity to view the harbor improvements some years ago in an Australasian port. The diver came up before his usual time, and brought with him an octopus that must have measured a good ten or twelve feet from tip to tip of tentacles. It was clinging to his back, twined round all his limbs, but fortunately had not anchored itself to any of the rocks or piles. The beast objected to his atmospheric bath and slid back into the sea through a two inch gap between the planks of the wharf.

Dangers of this kind are inevitable to the diver's art, but much has been done of late years to protect him from perils of faulty apparatus and inefficient means of communication. A number of these improvements are due to Messrs. C. E. Heinke & Co., of London. The pumps, dress, helmet and boots have all received attention.

Slight improvements have been made from time to time until the aggregate of changes has become very considerable. The old style diving dress was by no means a comfortable garment. The seams at the feet and neck leaked; the pressure of the wrist outlets numbed the hands; the cut of the sleeves prevented the hands being brought together at the front without great discomfort and chafing. It has at length been found how to make a foot with but one seam, how to form a watertight cuff without undue pressure, and how to reinforce seams without making the dress unwieldy and stiff. The latest pattern of boot consists of a solid brass casting for protection to the foot. An ingenious arrangement of straps prevents the foot being accidently withdrawn. Every detail of the equipment has received the same minute care.

For light, the diver is offered his choice of oil or electric lamps. The former is supplied with air through a branch hose from the air pump. The latter are fed by a special robust flexible cable. For communicating with the attendants above, there is a patent speaking apparatus that depends for its action on an extra air tube, fitted with sound discs in the diver's helmet. A more elaborate device consists of a telephone adapted for submarine work. Transmitter and receiver are suitably placed inside the helmet, and a call button operated by the diver's chin. The conductors can be embedded in the rubber wall of the air tube or in the life line. The equipment for the use of two divers working together makes provision for communication between them as well as to those on boat or land.

The uses to which this apparatus has been put form a romance in themselves. When the S. S. "Japan" was burned the first Heinke suit ordered was lost in a wreck. Another was then sent out, the first was recovered by its use, and both were then successfully employed to salve £77,000 worth of gold and silver coin in fused masses. Seven of the most celebrated divers have, by the use of this apparatus, salved between them over £10,000,000 of bullion and over 100 vessels. Another curious case was the recovery of a chased silver hunting knife valued at £7,000. This was recovered from the S. S. "Cadiz," wrecked off Ushant, after two months submersion.

In pearling, naked diving is being fast replaced by diving with apparatus, and it speaks well for the manufacturers that a round thousand of Heinke outfits are in daily use by semi-savage operators.

Homelier uses for this apparatus are found in dock and harbor constructions, dock working and maintenance, emergency ship repairs and a hundred and one other branches of the marine industry. For all purposes, over seven hundred equipments are turned out yearly.—*Far Eastern Review.*

Hammer drills are used near Atlin, British Columbia, in breaking lumps of frozen gravel. The bit used is sharpened as is a moil, and cuts into the clay and gravel quickly. The vibration of the drill seems to shatter the material and, by prying a little, lumps as much as ten feet in diameter can be broken.

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THE STORM KING WATER TUNNEL

The "holing through" of the Storm King tunnel under the Hudson, which was accomplished on Jan. 30, was recognized by the engineering world, by the residents of New York City and by the general public as an event of the greatest importance, and it was celebrated with all the ceremony which circumstances at the time permitted. A party of eminent engineers, of New York City officials and others were conveyed by special train, and after they were lowered to the bottom of the east shaft Mayor Gaynor closed a switch which fired the final blast that brought the advance headings from the opposite shores together. Then the party walked through the tunnel to the point of junction, speeches of congratulation were made and toasts were drunk according to time honored custom.

This is one of the most important and responsible bits of tunnel work that has ever been executed. It runs practically level between the shafts on each side of the river 1,200 feet below the water, making it by far the deepest water tunnel in the world. When the great aqueduct was being planned to convey a sufficient supply of water from the Catskill Mountains to the Metropolis the most difficult detail to determine was the crossing under the Hudson. When the location was decided upon unexpected difficulties developed from the unsoundness of the rock which the borings revealed, and it took some years of ingenious and persistent piercing of the rock to great depths before assurance could be given that the material to be encountered would be safe to drive the tunnel through. The result has fully corroborated the assurance given by the preliminary investigations, so that the rock actually encountered was exceptionally sound and free from water and the tunnel was finally driven in almost record time.

With this tunnel under the Hudson now assured the date of conpletion of the entire work can be promised with practical certainty, and it will be permissible to speak of the great undertaking as a whole. It is not only one of the world's great engineering achievements, but it is a great historical event as well, touching the lives and habits of millions of people and compelling comparison with the aqueducts of Rome in her glory.

The great need of the ancient city, as of

the modern, was a copious and reliable supply of water. Water is generally abundant if we seek far enough for it, and the problem has been in either case simply to collect and store and deliver it where and when required, and for this the highest engineering talent of either age has been employed. The remains of the ancient works show the limitations as well as the constructive ability of the age. The engineer necessarily planned according to his means of execution. He had not the high explosives and he had not learned to use compressed air, either for operating his rock piercing and cutting tools or for resisting water pressures when encountered, and so he could not burrow deep into the rocks and his aqueducts were necessarily built as artificial rivers giving the water an easy, open flow for whatever distances might be required. To cross the valleys some monumental and enduring structures were erected which are architectural wonders to the present day.

The pressure aqueduct of the moderns has nothing for the eye, but it serves its purpose most effectively and is in nothing perhaps more astonishing than in the rapidity with which it can be constructed from beginning to end. The greatest engineering works of recent years all on the American continent, have been the Panama Canal, the New York State Barge Canal and the Catskill Aqeduct. The latter, the latest to be planned, will be the first to be completed and put into full service. It is completely indebted to Compressed Air for its existence and could not have been built, could not have been planned or thought of, without it. There are therefore none who can more properly exult in the successful completion of the work than Compressed Air Magazine.

THE STORM KING TUNNELING RECORD

A remarkable speed record was made in the driving of the Storm King tunnel, although the conditions under which the work was done necessarily bar comparison with other tunneling records. All the material handled had to be hoisted through shafts on either side of the river 1,100 feet deep. The tunnel was driven all the way through hard granite to a clear diameter of 17 feet. This is to be lined with concrete, leaving a smooth finished interior 14 ft. 6 in. diameter.

The shafts had been sunk on each side of the river and about 200 feet of the tunnel had been driven at one end when, in June, 1911, the contract for the completion of the tunnel was let to the T. A. Gillespie Company, with the date of April, 1913, assigned for the completion of the work, including the concreting of the entire tunnel and the shafts. From the beginning of the work under this contract until the meeting of the headings on January 30, 1911, over 2,500 feet of tunnel was driven at an average rate for the two headings of over 360 feet per month. On the heading driven from the west shaft there was maintained an average rate of progress of 265 feet per month for the distance driven of 1,744 feet.

FASHIONS IN TOOLS

There is a tyranny of fashion to which we are all subject in the texture, the cut and color of our garments, and, except for the changes which are made in recognition of the temperature conditions of the successive seasons, there would seem to be little more than an initiative caprice and then the imitative habit to account for them. There are changes of fashion also in our tools, in our ways and means of doing work, and for these it is to be hoped that more rational and satisfactory explanations may be found.

For one thing, it is to be expected that the changes of fashion in our tools shall lead to better work or more easy and prolific accomplishment, and this expectation we are seeing constantly realized. Perhaps one of the most pronounced changes of fashion in our tools is occurring or has occurred, we may say, within the century which is still young, and in one of the most strenuous and exacting of our industries. We have to recognize the fact that in certain lines of rock drilling the hammer drill is becoming the fashion, and the percussion drill is no longer sure of universal employment. This changing fashion is not born of caprice nor extended by servile imitation, but is dictated by judgment and experience and endorsed by practical results.

The change of fashion from the percussion drill to the hammer drill is, as often happens with all our fashions, not the exploiting of a novelty but a reversion to the fashion which prevailed long ago. The hammer drill works upon the same principle as the hand drill,

while the reciprocating bit-carrying piston was a distinct and radical departure in mode of operation from the hand-held sledge-driven drill which it displaced, and in results accomplished so greatly excelled. It would seem now that the persistent success of the reciprocating drill is to be attributed to other features and accompaniments rather than to the reciprocating principle in itself.

Indeed, it is not easy to understand why the inventors of the first power rock drills did not imitate the hand drill operation. The hammer drill does. The bit is pressed tightly and constantly against the rock and the hammer blows are showered upon it with a sharpness and rapidity little to be compared with the thud, thud of the heavy piston-carried bit. No matter how deep may be the hole, within the working limits of the drill, or how much the hole may be choked by the accumulation of mud, the stroke of the hammer is just as sharp and quick at all times, which is very different from the operating action and effect of the reciprocating bit.

The discarding of cumbrous appurtenances, the lightness of the hammer drill itself and the means of placing it and holding it to its work, as compared with its predecessor, give it perhaps its greatest advantage when it comes to counting up the work done and the cost of it.

It is, in the first place, a one-man instead of a two-man or a three-man drill. It dispenses with the tripod and the heavy weights to hold it down, and it has as little use for the column or bar with their jack screws to be so carefully set up and so constantly watched. The drill is just lifted to the required position and then a puff of air not only holds it securely but also does the feeding when in operation. The drill, therefore, like the express train, makes much of its gains by shortening its stops and keeping more constantly at it.

We must keep up with the fashions in dress, or life is not worth living, and in the competitions of business following the tool fashions is still more imperative, for without them progress ceases and success departs. The fashions in either line rarely originate with those who follow or adopt them. Those who originate the tool fashions have great responsibilities, and they only hold their own by keeping always in the lead.

AVIATION AND ARTERIAL PRESSURE

The constantly increasing application of the aeroplane to such practical uses as cross-country flying, and delivery of letters and parcels, the location of submarine boats and mines by reconnoitering above the water (a feat recently successfully accomplished in France), and the carrying of passengers, directs attention anew to the importance to the aviator of an exact knowledge of the powers and the limitations of his own body. Marvelous as is the human machine in its powers of recuperation after injury or strain, it has the disadvantage that it cannot be reassembled when once shattered, and worn-out portions cannot be replaced by new ones ordered from a factory—facts that reckless young aviators are apt to ignore.

Of especial importance is it to the aviator to know the condition and capacity of his heart and arteries, because of the severe strain put on them by the rapidity of movement, the fluctuations of air-pressure, the concentration of attention demanded, and the ever possible violent excitement of sudden danger. If "the motor is the heart of the flying-machine," the heart is the motor of the human machine, and in either case a defective motor is the gravest source of catastrophe.

Altitude flying has a peculiarly disturbing effect on the heart, not only because of its intimate association and co-operation with the lungs, but because of the variations in arterial pressure produced by changes in the density of the atmosphere, and the fact that the tremendous rapidity of ascent and descent does not afford time for the proper adjustment of the internal to the external pressure. It has been said that the torpor which affects some aviators in too swift ascent or descent, and which is held responsible for many fatal accidents, comes from insufficient responsiveness of the arteries to changed pressure conditions, and this is easy to comprehend, since whatever affects arterial pressure must affect the supply of blood to the brain.

In this connection a very curious and significant discovery has just been announced by Dr. P. Bonnier. It has long been known that the *medulla oblongata*, the bulbous mass of gray and white nerve matter situated at the top of the spinal cord, governs the involuntary actions of heart and lungs. This is the reason why injuries to the neck are so uniformly fatal

in nearly all instances, while life may be prolonged for years when other portions of the spinal cord or the brain itself have been injured. Dr. Bonnier has now shown the existence in the *medulla* of manostatic centers whose function it is to produce an equilibrium between the interior pressure of the blood and the exterior pressure of the atmosphere.

Furthermore, in subjects whose arterial pressure is supernormal because of defective action of the nerve centers, he has proven the possibility of rousing the activity of these by means of a very simple operation, consisting of a slight nasal cauterization at a point connected with the area of the *medulla* where the centers in question are found. The return of the arterial tension to the normal following the operation is often immediate and seems to be permanent, though judgment must be suspended on this point until the early experiments are confirmed.

However, Dr. Bonnier cites one case of greater interest—that of a young man who suffered from circulatory oppression and dizziness at each descent. His arterial tension was regulated and reduced from 22 to 16, a tension which has been normally maintained ever since (a period of four months at the time of writing), with the result that he has experienced only a slight discomfort in place of his former oppressive sensations during descent. Thus it would seem that in some instances, at any rate, the aviator may be able to control his arterial tension and "regulate his manostatic capacity with as much care as his motor."—*Scientific American Supplement.*

MILITARY AEROPLANES

The difficulties in the way of rendering an aeroplane a thoroughly practical machine have been strongly emphasized during the trials of military types held at Rheims in October, 1911. Even in its present form the aeroplane is of great utility, and no one will contest its value for military purposes in view of the work it is doing in Tripoli, where it has, on more than one occasion, been of marked value to the Italians.

But the aeroplane does not yet satisfy military requirements. It must carry at least one observer in addition to the pilot; it must be able to resume its flight unaided on any ground where it may happen to alight; and it must be absolutely reliable. The conditions imposed by the French military authorities are very severe, but this has not debarred makers from doing their best to satisfy them. The machines at Rheims are nearly all fitted with engines of 100 to 140 horse power. There are monoplanes and biplanes and triplanes, and a machine with four engines which can be run separately or simuleaneously for varying speed. There has been a good deal of controversy as to whether the monoplane or multiplane is preferable for military work, but no light has been thrown on this matter at Rheims, for the reason that up to the present time it has been impossible, on account of the weather, to carry out the programme.

Two or three men have been killed during the experiments, but, on the other hand, Vidart has done some surprising work with a monoplane when caught at a fairly high altitude in a storm. So far as they have gone the trials of these powerful machines under favorable weather conditions have not given altogether encouraging results. Meanwhile, the Wright brothers claim that they are in a fair way to perfecting a machine which will hover in a breeze and will only need an engine of small power. It is by experiments like these that we may hope to see the design of aeroplanes saved from the rut into which it appears to be descending.—*The Engineer,* London.

NEW TYPE OF LOCOMOTIVE

An interesting and novel type of locomotive is being developed under the patents of James Dunlop, of Glasgow. It is driven by compressed air, which is supplied by an oil engine-driven compressor. The compressed air is used on the closed circuit, sometimes called the dense-air system, in which a certain quantity of air passes continuously from the compressor to the engine or driving air motor, and then back to the compressor again. Leakage is automatically made up by a small auxiliary compressor. It is claimed that the closed circuit system is more efficient than the open-circuit system in which fresh air is continuously being taken in by the compressor and the exhaust from the motor rejected to atmosphere. In the closed circuit system the average air pressure throughout the system is maintained at some figure, say 150 pounds per square inch, the intake pressure at the motor

being higher and the outlet lower. The range of pressure is governed by the control of the compressor and the cut-off of the motor. The compressor may be controlled by varying its speed, but more usually by altering the number of cylinders in action, this being done by lifting the air delivery valves off their seats in those cylinders to be put out of action. The air in the delivery main is then merely drawn in and pushed out through the open valve. Whether the high efficiency claimed will be attained remains to be tested. In this case it is possible to increase the economy materially by heating the air before it enters the motor cylinders by means of the exhaust gases from the oil engine. It is claimed that the fuel cost will be $2.19 per 1,000 effective horsepower hours with oil at $10 a ton, as against $3.80 for a steam locomotive with coal at $2.50. These costs are based on 0.51 pound of oil per b. h. p. at the engine, a recovery of 16 per cent. of the heat in the exhaust gases, and a mechanical efficiency for the locomotive of 90 per cent. For the steam locomotive 3½ pounds of coal per h. p. hour has been allowed. The calculations for the air locomotive seem to be based on quite the most favorable conditions, and it would be surprising if the average results were nearly so good under service conditions. The system is, however, a very interesting attempt to utilize the non-reversing internal combustion engine for locomotive work, and the practical results will be eagerly looked for.

NOTES

The six gas engines being installed as the initial group in the new power house of the Indiana Steel Co. at Gary, Ind., are the largest units ever constructed, and have a rating of 3,200 kilowatts (4,288 H. P.) each. The new engines are of the twin tandem double-acting Allis-Chalmers type, with cylinders 44 by 60 in. The engines will operate on blast furnace gas, and are to drive alternators delivering 6,600-volt, 25-cycle, 3-phase energy to the power network of the Gary mills.

The first step in preliminary construction preparatory to building the highest dam in the world has been accomplished in the completion of the mammoth diversion tunnel at Arrowrock dam, Boise irrigation project, Idaho. This tunnel, when lined with cement, will be 25 feet high and 30 feet wide, larger than a double track railroad tunnel, and will carry the whole flow of the Boise River during the construction of Arrowrock dam. The tunnel is 470 feet long and driven through solid granite for its entire length. Its excavation was completed several days ahead of schedule time.

A Prominent Maker of Air Compressors is in need of three experienced and efficient salesmen. State in detail previous experience, references and compensation expected. Answer in hand writing. Address COMPRESSED AIR MAGAZINE.

The use of fertilizers, in which potassium salts are essential constituents, is constantly growing, and it is interesting to note, in passing, that a bank in Illinois has established a loan fund, free of interest, to enable the farmers of that district to invest more freely in fertilizers and to raise correspondingly larger crops.

The first city subway in Italy is to be constructed at Naples at a cost of $3,000,000. The line will be both urban and interurban, the former with a total length of 8 kilometers (4.97 miles) and the latter 10 kilometers (6.21 miles) and is to be completed in four years. Similar projects are under consideration both at Genoa and Rome.

Winthrop Talbot, M. D., in an address before the recent convention of the National Association of Machine Tool Builders, said that from experiments carried on under his direction, it was found that the greatest average comfort from surrounding air conditions came from a temperature of 65 to 70 degrees, a relative accompanying humidity of 50 to 60 per cent. and an air velocity of from 2 to 5 feet per minute.

In the acetylene-burning lighthouses along the Panama canal will be installed copper cylinders exposed to the sun. When the sun rises in the morning and the rays fall upon these cylinders they will expand and close valves that admit gas to the burners. As night approaches and the sun's rays diminish

in power the cylinders will contract and again turn on the gas, which will be ignited by small pilot jets.

Professor Jamieson, of the Oklahoma State Normal School, some time ago on a foggy morning discharged into the atmosphere some liquid air—and afterwards it rained. He says that he is going to take an airship and try the liquid air above the clouds, and he expects to cause considerable precipitation. His expector must work easily.

Experiments undertaken for measuring the temperature on the inner surface of the cylinder of a small gas engine have shown that the temperature is about 465 degrees F., and that the variation from cycle to cycle is usually less than 18 degrees F. The steady conditions of low temperature at the wall surface were caused by the jacket water, while very great changes of heat take place at a very short distance from the walls.

It is stated by Stewart W. Young (U. S. pat. No. 1,011,699) that by the use of a small cartridge containing ammonium carbonate, 65 per cent.; potassium bichromate, 33 per cent.; and camphor, 2 per cent., in holes containing high explosives, the gases will be rendered inoffensive. A somewhat cheaper composition which he also proposes (U. S. pt. 1,007,409), is a mixture of 65 parts ammonium carbonate and 35 parts of manganese dioxide.

According to the *Brass World,* a recent experiment in copper melting in an electric furnace produced a peculiar physiological action. Some 5,000 pounds of pure eletrolytic copper were melted in a three-phase arc furnace. After a few hours all of the 10 men employed experienced difficulty in breathing. For the following 24 hours the men were attacked with a severe nausea, followed by a soreness of the entire system similar to that of acute grippe.

The Los Angeles Aqueduct is progressing at a rate which promises completion early in 1913. On December 15, 1911, the last tunnel of the Little Lake Division, Tunnel 10A, was holed through. This tunnel, 5,960 feet long, is fifth in length on the Aqueduct; the longest, the Elizabeth Lake Tunnel, 26,870 feet, was completed early in the current year. Tunnel 10A was begun March 10, 1910. Its completion leaves only about 4,000 feet of tunneling to be done on the Aqueduct, out of a total of nearly 43 miles.

After the experience in cutting with a hacksaw the heavy steel bars which guarded the windows of the Equitable Building, in order to rescue men in the cellar, the New York Fire Department has ordered portable oxyacetylene outfits for the down-town districts. With the mercury hovering around zero, the hacksaw is a very slow proposition, particularly for the man whose life depends on the bars being sawed before the fire reaches him. This is supposed to be the first instance of these outfits being used by fire departments.

A room may be too damp for human occupancy, without showing the growth of molds or mildews, or the formation of crystals upon the walls. In order to test the habitability of a room with respect to humidity, *Le Journal de la Sante* recommends placing about two pounds of freshly slaked lime in the room, sealing up all doors and windows tightly, and leaving for twenty-four hours. If the increase in weight during this time (absorption of water) exceeds ten per cent. of the weight of the lime, the room should not be considered healthful.

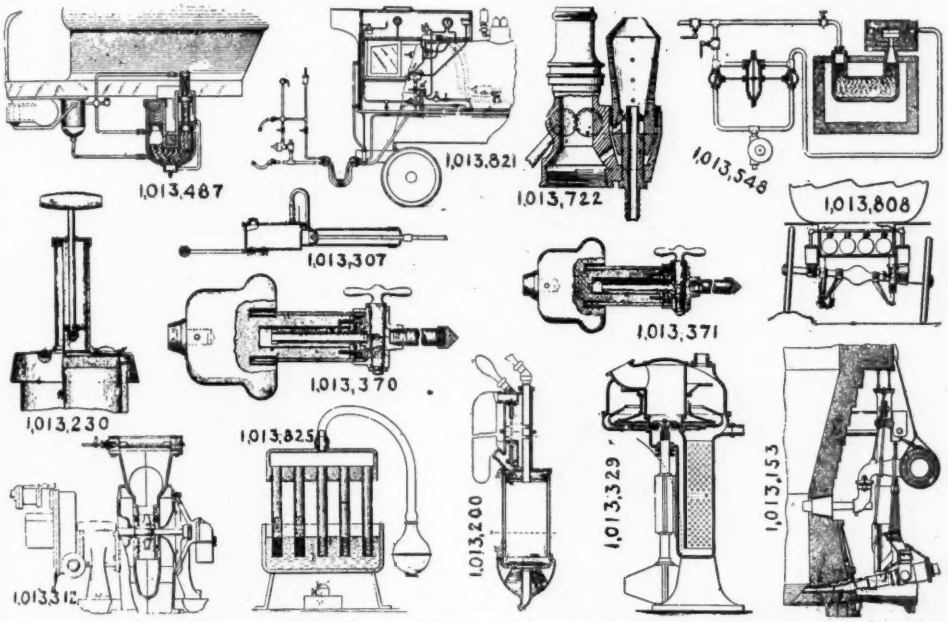
The following color scheme for piping is from a German gas journal: Red means fire, whether it is a hydrant, bucket, axe or anything else. Green is for water pipes; blue, for air; white, steam; black, tar; rose, ammonia or alkalies; brown, oil; gray, vacuum; rose with red stripe, acids. Yellow is a general color for gases. If the yellow is alone, it means purified blast furnace gas, or if with a black ring, it is not purified; yellow with a blue ring means producer gas; with a rose-colored ring, illuminating or coke-oven gas; a green ring means water gas, and a brown ring oil gas.

The construction of a freight tunnel under the Hudson River, to be built by New York and New Jersey, is proposed as part of a plan for the comprehensive development of the port of New York. It is suggested that the rates be fixed by the Interstate Commerce

Commission, as it is believed that this arrangement would abolish terminal competition. Some years ago a freight tunnel was proposed as part of a shore-line tunnel extending around the lower part of Manhattan Island, both the Manhattan and the Hudson River Tunnels to be connected with an assembling and distributing station in New York.

The solid crust of the earth, with a specific gravity of only about 2.5, as against 5.7 for the entire globe (crust and liquid or semi-liquid interior) is said by Rosenbusch to consist of the various elements in the following proportions by weight: Oxygen, 47.29 per cent.; silicon, 27.21; aluminium, 7.81; iron, 5.46; calcium, 3.77; magnesium, 2.68; sodium, 2.36; potassium, 2.40; hydrogen, 0.21; titanium, 0.33; carbon, 0.22; chlorine, 0.01; phosphorus, 0.10; manganese, 0.08; sulphur, 0.03; barium, 0.03; chromium, 0.01.

Writing in the *Journal of Gas Lighting*, Mr. Alwyne Meade describes a system of "sand spraying" iron or steel to prevent corrosion. With this method, a thin coating of fine silver sand is sprayed on to the paint while the latter is still wet. The paint is allowed to dry, another coat is then applied, and this also sprayed with sand, and finally a third coat is put on, but the sand is not sprayed on to this. When the whole has thoroughly dried, the sand combines with the paint and forms a hard shell, which is very much better able to resist the inroads of the rust-producing agents. This method is particularly adapted for use with mild steel plates and rolled steel beams; and in all cases the writer recommends that the particular object being treated should be thoroughly scraped and brushed with a wire brush, and a coat of red-lead paint—without the sand spray—should be applied before the painting as suggested above is commenced. This coat should follow immediately after cleaning.



PNEUMATIC PATENTS, JANUARY 2.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

JANUARY 2.

1,013,121. FLUID-OPERATING MECHANISM. ARTHUR AUGUSTUS BROOKS, Ashton-upon-Mersey, England.

1,013,147. VACUUM CLEANING APPARATUS. LOUIS W. G. FLYNT, Rochester, N. Y.

1,013,153. CLAY-GUN. FREDERICK H. N. GERWIG, Pittsburgh, Pa.

1,013,200. VACUUM-PRODUCING APPARATUS. JOSEPH F. MENNINGEN, West Allis, Wis.; Katherine Menningen administratrix of said Joseph F. Menningen, deceased.

1,013,230. VACUUM PACKING APPARATUS. GRAY STAUNTON, Evanston, Ill.

1,013,259. PNEUMATIC VALVE - ACTION. FRANK L. YETTS, New York, N. Y.

1,013,307. SPRAYER. JOHN FRANKLIN PATTERSON, Warren, Ohio.

1,013,312. CENTRIFUGAL COMPRESSOR AND PUMP. RICHARD H. RICE, Lynn, Mass.

1,013,329. CENTRIFUGAL PUMP OR COMPRESSOR. FRITZ STROHBACH, Charlottenburg, Germany.

1,013,370. FLUID-PRESSURE COMPRESSION OR HOLDING DEVICE. JOSEPH BOYER, St. Louis, Mo.

1,013,371. PNEUMATIC RIVET-HOLDER. JOSEPH BOYER, Detroit, Mich.

1,013,460. PROCESS OF PREPARING NITROGENOUS COMPOUNDS. LELAND L. SUMMERS, Chicago, Ill.

1. The process of preparing nitrogenous compounds which consists in introducing into heated carbonaceous material liquefied gas containing nitrogen.

1,013,772. HUMIDIFIER. ROBERT C. HERREN, Kenton, Ohio.

1,013,808. PNEUMATIC SPRING FOR VEHICLES. CHARLES R. PALMER, Cincinnati, Ohio.

1,013,821. SAFETY DEVICE FOR FLUID-PRESSURE BRAKE SYSTEMS. WILLIAM H. SAUVAGE, New York, N. Y.

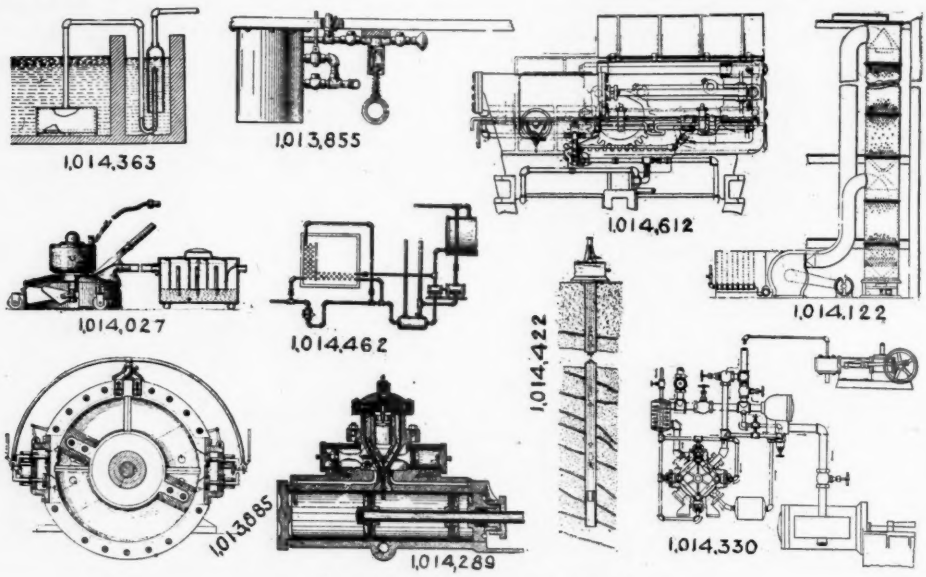
1,013,825. METHOD OF PRODUCING MOUTH-PIECES ON CIGARETTES. LEWIS H. SONDHEIM, New York, N. Y.

1. A method of forming mouth-pieces on cigarettes, consisting in impregnating an end thereof with a binding substance, and producing an air current therethrough.

JANUARY 9.

1,013,855. VEHICLE-SPRING. WARREN W. ANNABLE, Grand Rapids, Mich.

2. In combination with a vehicle, a pneumatic



PNEUMATIC PATENTS, JANUARY 9.

1,013,487. PNEUMATIC SPRING FOR VEHICLES. LUCIEN R. GRUSS, Chico, Cal.

1,013,528. COMBINED INTERNAL-COMBUSTION AND COMPRESSED-AIR ENGINE. JOHN K. BRODERICK, St. Louis, Mo.

1,013,548. ART OF MAKING CASTINGS. CHARLES M. GREY, East Orange, N. J.

1. In the art of making castings, the process which consists in confining fluid material in two chambers having communication beneath the surface of said material, and producing a partial vacuum in the said two chambers above the metal therein by exhausting air from both of said chambers.

1,013,690-1. APPARATUS FOR TREATING SNAP-BOLLS. JAMES A. SHIELDS, Atlanta, Ga.

1. The process of treating snap bolls for the recovery of the fiber thereof, consisting in crushing said bolls; transferring the crushed bolls by suction; separating the boll husks from the fiber; transferring the fiber by an air blast to make it fluffy and finally ginning the fiber, substantially as described.

1,013,722. AIR-PURIFYING INHALER ATTACHMENT. SAMUEL BANTA and BENJAMIN L. STOWE, Jersey City, N. J.

1,013,730. VACUUM-TRAP. JOHN A. BEMISH, Rochester, N. Y.

spring, a pump to supply compressed air to the spring and mounted on the body of the vehicle, a rod movably connected to the pump piston at one end and attached to the spring support at the other end, and a spring yieldingly engaging the piston to operate the same.

1,013,885. FLUID-PRESSURE MOTOR. JOSEPH MCCONNELL, Connellsville, Pa.

1,014,027. PNEUMATIC CARPET-SWEEPER. DAVID C. WALTER, Toledo, Ohio.

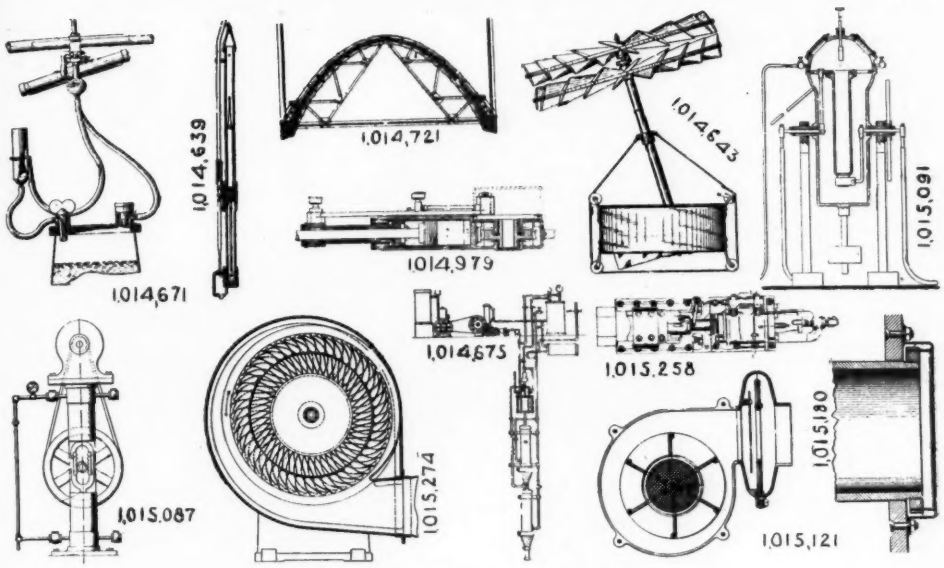
1,014,122. GRAIN-DRIER. JOHN B. CORNWALL, Moline, Ill.

1,014,289. PUMP. SAMUEL E. FOLK, Bryan, Ohio.

1. In an apparatus of the class described, the combination with a pump, fluid pressure actuated mechanism for operating said pump, and a closed receptacle to which fluid is delivered by said pump, of means associated with said mechanism and actuated by both fluid pressure therein and by pressure within said receptacle for automatically controlling the passage of the actuating fluid to or around said pump actuating mechanism.

1,014,330. APPARATUS FOR HEATING COMPRESSED AIR. SIDNEY A. REEVE, Worcester, Mass.

1,014,347. HOT-AIR HEATER. HENRY STRAND, Cleveland, Ohio.



PNEUMATIC PATENTS, JANUARY 16.

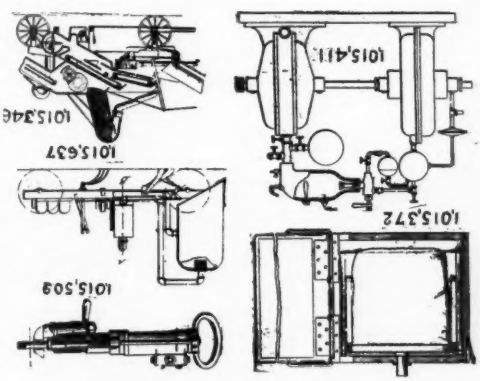
1,014,363. AIR-FLUSHING APPARATUS. HUBERT BEDDOES, Philadelphia, Pa.
1,014,364. PNEUMATIC PIANO. WILLIAM G. BETZ, Chicago Heights, Ill.
1,014,422. COMPRESSED-AIR PUMP. WILLIAM E. STUART, San Francisco, Cal.
1,014,62. DRYING SYSTEM. WILLIAM M. GROSVENOR, Grantwood, N. J.
1,014,545. AUTOPNEUMATIC PLAYING DEVICE FOR MUSICAL INSTRUMENTS. CHARLES WARREN, Rockford, Ill.
1,014,612. DUMPING-CAR. ERWIN C. SHERMAN, WILLIAM W. MCKELVEY, and EDGAR J. REILLY, Youngstown, Ohio.
2. A dumping car, a fluid pressure motor geared to the car to effect the dumping movements thereof, a source of fluid pressure supply for the motor, and valve means for controlling the operation of the motor to dump the car at an increasing velocity during the last portion of such movement, substantially as described.

JANUARY 16.

1,014,639. PNEUMATIC HAMMER FOR DRIVING NAILS. WILLIAM EVANS COLWELL, Kincardine, Ontario, Canada.
1,014,643. AERIAL VESSEL. JOHN J. DONNELLY, Denver, Colo.
1,014,671. MILKING APPARATUS. DAVID TOWNSEND SHARPLES, West Chester, Pa.
1,014,675. PUMP. ISAAC R. STOUT, Medicine Lodge, Kans.
1,014,721. PNEUMATIC CAISSON OF FERRO-CONCRETE. STANISLAW RECHNIEWSKI, St. Petersburg, Russia.
1,014,729. VACUUM - CONTROLLER FOR PNEUMATIC CLEANING APPARATUS. JOHN STROTHER THURMAN and JOHN ALEXANDER DUNLAP, St. Louis, Mo.
1,014,778-9. PNEUMATIC STACKER. JOSEPH K. SHARPE, Jr., Indianapolis, Ind.
1,014,979. PERCUSSIVE DRILL, HAMMER, OR LIKE PERCUSSIVE TOOL OR MACHINE. ALFRED SYKES, Huddersfield, England.
1,015,087. AIR-PUMP. GOTTFRIED SCHMIDT, Hazleton, Pa.
1,015,091. APPARATUS FOR MELTING AND MIXING METALS IN VACUUMS. WILLIAM SPEIRS SIMPSON, London, England.
1,015,121. HAIR-DRIER. ALFRED BARKER, Philadelphia, Pa.
1,015,180. FLUID-TIGHT EXPANSION-JOINT. CHARLES EASTON HEITMAN, New York, N. Y.
1,015,258. CHANNELING-MACHINE. ALBERT BALL, Claremont, N. H.
1,015,274. CENTRIFUGAL FAN. JAMES KEITH, London, England.

JANUARY 23.

1,015,346. SUCTION DEVICE FOR CORN-SHELLING MACHINES. CLYDE M. RUSHING and ALBERT J. WHEELER, Charleston, Mo.
1,015,372. PNEUMATIC CLEANING - MACHINE. MORRIS S. WRIGHT, Worcester, Mass.
1,015,411. MOTOR. SAMUEL J. WEBB, Minden, La.
1. An apparatus of the class described comprising a source of compressed air, means for maintaining the pressure of the air below a predetermined amount, a working fluid generating chamber, a fuel supply chamber, a mixer, means connecting the source of compressed air with said mixer, means connecting the fuel chamber with said mixer, means connecting the source of compressed air with said fuel chamber, means connecting said mixer with said generating



PNEUMATIC PATENTS, JANUARY 23.

chamber, and a safety valve on said generating chamber and adapted to maintain the pressure in said generating chamber below the pressure in said source of compressed air.

1,015,509. HAMMER-DRILL. WILLIAM PRELLWITZ, Easton, Pa.

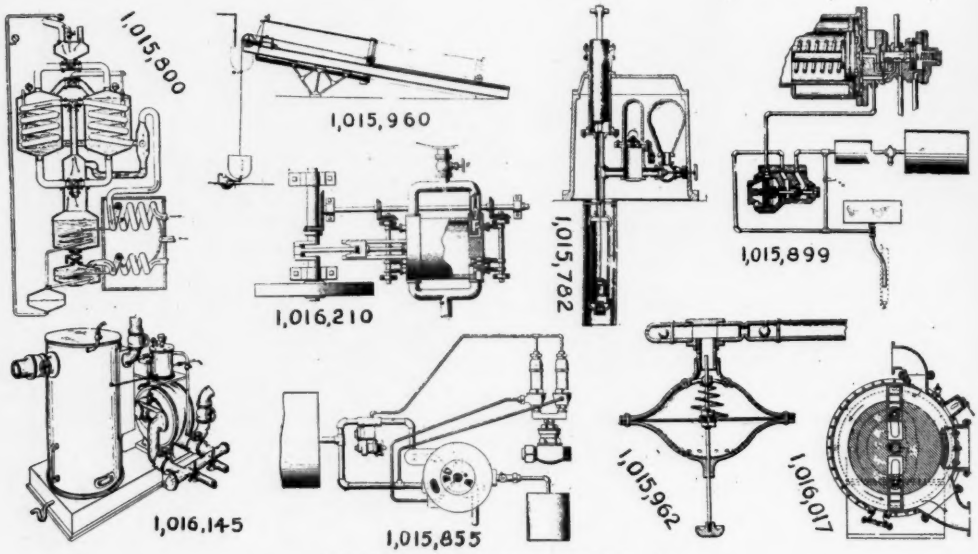
1,015,637. STREET-CLEANING MACHINE. LE ROY H. ROBY, Fostoria, Ohio.

JANUARY 30.

1,015,782. PUMPING APPARATUS. XENOPHON CAVERNO, Kewanee, Ill.

1,015,800. PROCESS OF LIQUEFYING AIR AND SEPARATING IT INTO ITS ELEMENTS. ERNST JANECKE, Hanover, Germany.

A process of liquefying air and separating it into its elements, consisting of liquefying air under pressure by bringing it into indirect thermal contact with a liquid rich in liquid oxygen whereby the said liquid is made to evaporate, then bringing a given quantity of the liquid air so produced into indirect thermal contact with the vapors given off by the liquid rich in oxygen, causing a part of said liquid air to evaporate at less than atmospheric pressure, thus causing a part of the vapors given off by the liquid rich in oxygen to reliquefy, and then adding the part of the liquid air not evaporated and the liquid obtained by the partial condensation of the vapors to the liquid rich in oxygen.



PNEUMATIC PATENTS, JANUARY 30.

1,015,824. DUPLEX PRESSURE-CONTROL APPARATUS. HOWARD M. P. MURPHY, Pittsburgh, Pa.

1,015,855. DUPLEX PRESSURE-CONTROL APPARATUS. WALTER V. TURNER, Edgewood, Pa.

1,015,875. HYDROGEN-GAS GENERATOR. WILLIAM LEONARD DOLBEN, Chicago, Ill.

1,015,894. VACUUM-CURRYCOMB. WILLIAM H. KELLER, Philadelphia, Pa.

1,015,899. AUTOMATIC TRACK-SANDING DEVICE. FREMONT P. LIVINGSTON, Denver, Colo.

1,015,921. AIR-MOTOR GEAR. CARL J. ZIRBEL, Montezuma, Iowa.

1,015,960. SLIMES-FILTERING APPARATUS. DAVID J. KELLY, Salt Lake City, Utah.

1. In apparatus of the character described, the combination with a tank having an open end, a filter-carrier movable in and out of the tank, and provided with a head adapted to close the open end of the tank, locking mechanism between the head and tank, and a fluid-pressure mechanism for actuating the locking mechanism.

1,015,962. PNEUMATIC PUSH-BUTTON AND PUMP. GEORGE A. KENNER, Herrin, and WILLIAM H. MICHAEL and THOMAS J. BURTON, Murphysboro, Ill.

1,016,004. MILKING-MACHINE. CYRIL EDMUND GANE, Normanby, New Zealand.

1,016,017. PNEUMATIC PUMP FOR LIFTING GRANULAR MATERIALS. EMILIAN KOLTSCHANOFF, Taganrog, Russia.

1. In a pneumatic pump for lifting grain and the like, the combination of a rotary pump provided with a suction-pipe and an outlet-pipe, the former for sucking the grain with the air into the space between vanes of the pump, and the latter for delivering the grain by the compression-action of the pump into the delivery pipe, and an air inlet valve in the space between vanes of the pump.

1,016,145. PROCESS OF DISINFECTING INCLOSED SPACES. GEORGE HARKER, Petersham, New South Wales, Australia.

1. The process of disinfecting which consists in charging a gas incapable of supporting combustion with a fluid disinfecting agent which, when mixed with air alone, is inflammable, the fluid mixture being constituted in such proportions as to be non-inflammable, and conducting such mixture to the point of use.

1,016,157. AIR COOLER AND PURIFIER. CARL JOST, Bombay, India.

1,016,161. FAN ATTACHMENT FOR ROCKING-CHAIRS. ERNEST C. KILLEBREW, Evansville, Ind.

1,016,210. MEANS FOR CONVERTING VAPOR ENERGY INTO WORK. ELZA J. CHRISTIE, Marion, Iowa.

2. In a motor adapted for the use of a mixture of steam and compressed air, the combination of a working cylinder having a reciprocating piston therein, and valves respectively adapted to admit atmospheric air at one stroke and to hold it in the cylinder while undergoing compression on the return stroke, another valve adapted to admit steam at the next succeeding stroke to commingle with the compressed air and final exhaust valve, and means for actuating these respective valves in due time and sequence.